

PART 6 | RISK ASSESSMENT AND MANAGEMENT

IT'S A RISKY BUSINESS—there are so many reasons why the objects in our care are at risk that it is surprising that they survive as long as they do. However, we manage those risks to ensure the long-term survival of the objects. Risk management is an integral component of museum operations to maximize the life expectancy and usefulness of the objects and their documentation. Staff responsible for museum registration should be directly involved in formulating and implementing the strategies to minimize overall risks to the collections.

This section provides an overview of the concept of risk management as it applies to the tasks associated with registration and management of museum collections. Some of the key operations that are components of risk-management strategies not covered elsewhere in this book are described more extensively—disaster planning, security and fire systems, integrated pest management, and insurance. However, it is critical to remember that a risk-management approach applies to any task or function that involves objects, including handling, photography, applying accession or catalog numbers, and storage.

Risk management is the process of evaluating the chance of loss or damage to an object and then implementing steps to avoid, minimize, or eliminate the risk. Conservation researchers, including Robert R. Waller, Stefan W. Michalski, and others at the Canadian Conservation Institute (CCI) have applied risk analysis theories and methods to preventive conservation resulting in a number of publications that provide strategies for how professionals who care for museum collections can apply risk management methods as decision-making tools for preventive conservation operations in museums (see bibliography). The general steps in formulating a risk management approach include:

- Establishing the context;
- Identifying the risks and assessing the potential magnitude of each risk;
- Identifying strategies to eliminate or mitigate the risks as well as costs and benefits of each strategy; and
- Setting priorities and establishing a plan to implement strategies, along with periodic evaluation and revision or modification of the strategies.

Many collection registration operations are developed by assessing one or two major risks and implementing appropriate strategies. *Risk-based decision making* expands this to apply to the assessment of most or all risks and then managing the risks on an institution-wide basis. Clearly this involves not only the collection registration staff, but also many other staff positions, to be effectively implemented. As a result of this assessment process, an institution may determine the need to transfer the assumption of risk through the use of insurance. This situation occurs when the institution identifies limits on its ability to mitigate potential risks to the collections.

Risks to collections are categorized according to ten basic types, commonly called the agents of collection deterioration—physical forces, fire, water, thieves and vandals, pests, pollutants, light and radiation, incorrect temperature, incorrect relative humidity, and dissociation.¹ Each type of risk is assessed and ranked according to its potential magnitude. At one end of the spectrum is total, catastrophic loss of the collection and its value; at the other end a mild, gradual, low-level loss of value. The identification and analysis of the risks is an essential precursor to the development of mitigation strategies.

Strategies for dealing with these agents of deterioration are based on five stages of controlling risks:

- Avoid the source;
- Block the agent;
- Detect or monitor the agent;
- Respond to mitigate the problem; and
- Recover from the problem or treat the damage caused by the problem.

There are eight possible levels of control that should be considered for each stage:

1. Location.
2. Site.
3. Building.
4. Room.
5. Cabinet.
6. Object or specimen.
7. Policy.
8. Procedures.

These parameters are for a collection, resulting in a matrix of possible strategies for mitigation. The costs and benefits of different strategies are assessed relative to the priorities for mitigating a particular type of risk. This process makes it possible to set institutional priorities and create a plan to ensure the implementation of controls to minimize the overall risks to the collection.

This risk-management approach applies to day-to-day decisions as well collection-wide, institution-wide decision making. For example, is there a risk to the collection if there is a change in the brand of ink used to number an object? Identify the risk, assess the potential magnitude of that risk, identify strategies to eliminate that risk, determine the cost and benefit to implement that strategy, and establish a control to mitigate the risk.

It is important to understand the risk management framework to place other functions in perspective. Why should a museum implement an integrated pest management program? Or develop emergency preparedness plans? Or assess the extent and quality of fire and security systems? In all cases, it is to minimize the overall risk to the collections. There will be limitations on the resources a museum has available. The museum may decide to transfer some risk, through insurance, to a commercial entity outside the museum. •

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Online Resources

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- American Institute for Conservation of Historic and Artistic Works Conservation Wiki. Available at: http://www.conservaion-wiki.com/wiki/Main_Page.
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dPlan (online program to build own plan). Available at: <https://www.nedcc.org/free-resources/dplan-the-online-disaster-planning-tool>.

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NOTE

1. Available at: <https://www.canada.ca/en/conservation-institute/services/agents-deterioration.html>.

IF AN EMERGENCY HAPPENED today, what would you do? How would you respond? What would be your first step? What would be your next step? When emergencies happen it instantly triggers many small and many huge questions, and you need to be able to respond to them thoughtfully and effectively.

In an emergency, the safety of visitors and employees takes precedent, but the institution is also responsible for its significant assets—the objects in its care. The safety of the collections depends greatly on the degree to which staff have thought about, researched, planned for, and prepared to respond to a crisis. The impact of an emergency gets progressively worse if the event is not dealt with quickly in a productive manner. The registrar or collections manager will be directly involved with developing readiness plans and responding to the crisis and should be a primary advocate for the collections.

The primary objectives of an emergency planning process are to:

- Identify the potential risks to avoid or minimize damage in an emergency.
- Implement steps now that can minimize damage when emergencies do occur.
- Retain control when an emergency occurs.
- Mitigate damage as quickly as possible.

Surprise is often a significant factor during an emergency, and peoples' emotional reactions to the crisis can impact rational thought processes and responses. A carefully thought-out emergency preparedness plan can be the key to minimizing the impact of a disaster or crisis, with a focus on responsibilities of staff members and procedures to be implemented during and after the event.

THE PLAN

The specifics of an emergency plan must be written down and made available in multiple formats, accessible both on site and remotely. The final plan needs to be easy to read, understand, and use. Backup resources are critical, but the initial reaction to a crisis has to be fast and a good plan, with respect to both content and a readable design, makes that feasible.

A readiness plan, or emergency preparedness plan, should contain sections that incorporate the following types of content, customized for the institution:

- Potential risks
 - Identify the greatest risks and hazards to the collections
 - Identify what can be done immediately to prevent or minimize damage
- Contacts and responsibilities
 - Chain of command
 - Individual staff member responsibilities
 - Duties of the response coordinator
 - Identify the coordinator for volunteers
 - Local emergency responders (e.g., fire department, medical, police)
- Initial assessment and immediate response to the event
 - Evacuation procedures with floor plans for safe exit routes
 - Floor plans with other essential information (e.g., potential safety hazards; shut-off valves; highest salvage priorities)

- Assessment of damage
 - Documentation of the damage (text and images)
 - Salvage priorities
- Mitigation plans
 - How-to steps for initial responses to different material types
 - Resources for follow-up, next steps
- Supplies
 - Checklists and suppliers contact information
 - Locations of supply kits
 - Maintenance checklist
- Forms
 - Damage assessment
 - Post-disaster report forms
- Resources
 - Contact lists for external, specialty services
 - Appendices with more details for specific types of events or mitigation efforts

The mechanics of producing an emergency preparedness plan will vary from institution to institution. The process of developing a plan requires time to assess the specifics of the institution and the collection with respect to the potential risk and time to develop effective responses. Although the process may have a lead staff member, the success of the plan depends on the involvement of key staff throughout an institution during the development of the plan. There is no single one-plan-fits-all-institutions and risks, but there are numerous resources easily available to help.

The first step in creating a plan is research and analysis. Identify potential risks and hazards that are specific to your collections and institution. Use general conservation surveys, collection assessments, and external sources such as the US Geological Survey's *Natural Hazards Gateway*¹ and the Federal Emergency Management Agency² (FEMA) to identify these risks. Use worksheets, such as the American Institute of Conservation (AIC) risk evaluation and prioritization worksheet³ to systematically consider

the full range of possibilities. Rank risks according to their likelihood and envision the worst-case scenario in each situation. What damage would each disaster cause? If not impacted directly, would your institution be used as a community center, with a potential for collection damages resulting from that use?

Part of the research phase includes locating pertinent resources and suppliers. Resource information includes the obvious (e.g., police, fire, medical response teams) but also the less obvious (e.g., dehumidifiers, oversized fans, or refrigerator semi-trucks). Investigate the appropriate responses and mitigation strategies for the types of materials that exist in the collection because this will determine what supplies you might need after an event. Easy access to critical supplies for immediate, quick response is essential to minimizing potential damage in many emergencies. Some regions host coalitions of cultural institutions that develop caches of supplies for emergency purposes or willing staff to help in a crisis.

Identify priorities for the rescue of collection objects and documents. Although this needs to be completed collection by collection, there should be an institutional priority listing. Time is always an issue in responding to an emergency, so the tough decisions of prioritizing what objects or documents should be rescued first need to be made in advance.

Responsibilities for decision making and implementation of tasks must be clarified in advance (and communicated to the chain of command). Time will be critical; during the emergency event is not the time to try to decide who should do what. Identify which staff members will be needed to respond to a disaster and what their responsibilities and duties will be. Decide who has the right personality and skills to direct response and recovery efforts; this does not have to be, and often should not be, the museum's director. Assign specific jobs to specific people so that everyone knows exactly what is expected of them, which will help to prevent a chaotic environment as the emergency unfolds. Regardless of the size of the organization, roles that typically need to be assigned include a response leader, liaison to emergency responders, health and safety officer, security and facilities person, administration and financial support, supplies and equipment, communications,

assessment, documentation, and salvage. Assigning one coordinator to manage volunteers is the most effective way to use this labor pool. Schedule training sessions to help everyone understand their role—and what they should not try to do.

The format of the final product should be a practical, useful document. A sectioned, three-ring binder allows for easy updating and easy access to content. Copies of the binder should be kept off-site as well as in the museum departments with key responding staff. In addition, there should be a small, shorter, and easy-to-reference response guide for all staff. The staff member who first responds to an emergency situation may not be a trained collections care staff person and, thus, will need to know how to handle decisions relating to the collection. Electronic copies of the plan are essential, but in the case of a power outage, hard copies are critical.

The plan should be reviewed and revised on a regular schedule, at least once each year. At the time of plan revision, the supply kits should be checked and replenished if necessary. Mock emergency drills allow staff to practice for visitor and employee safety as well as how to minimize damage to collections. The written emergency preparedness plan should always be considered a work in progress and should undergo regular evaluation and updating.

RESPONSE AND RECOVERY

The first few hours and days after an emergency are critical to minimize damage and, just as importantly, to prevent additional damage from well-intentioned but incorrect actions. In addition to the immediate response, which might, in fact, take several days, weeks, or even months, there is a recovery phase during which salvage and mitigation activities occur. The recovery phase can take years but is marked by a consistent, controlled process with carefully thought-out actions to mitigate damage from the emergency.

A calm, orderly, and deliberate approach is key to a professional, effective staff response, regardless of the size of the emergency. Safety for staff and visitors is always an overarching concern and should be paramount throughout response and recovery. In the initial response, during evacuation, consciously and sys-

tematically look for hazards—frayed or loose electrical wires, fallen objects that might trip someone, broken glass, etc. Guide the staff and visitors away from hazards. Staff should not re-enter an emergency area until cleared to do so by professional emergency responders. Although this approach may seem to be common sense, we all know professionals whose first thought of safety will be for the objects and not the people!

Calm and deliberate should be the mantra for staff response. This helps defuse anxiety and deflect frantic, instinctive actions that often result in mishandling of objects and increased levels of damage. Rely on the chain-of-command structure and the response coordinator to plan and implement appropriate steps. Recognize that in a catastrophic emergency, access to collections may be significantly delayed. In a minor emergency, access should be delayed intentionally—long enough to assess the situation and think ahead to the next steps that are the appropriate and best response for this particular situation.

Steps in response to an emergency include:

- Implementation of emergency notifications;
- Securing of the area;
- Identification of the source of the problem;
- Notification of the insurance contact;
- Assembling the response team;
- Conducting the initial assessment for hazards and damage;
- Documentation;
- Protection of the highest priority collections;
- Stabilization of temperature and humidity;
- Planning the next steps;
- Gathering supplies and equipment;
- Contacting and initiating specialized services;
- Setting up work spaces and implementing salvage activities; and
- Documenting, communicating, and coordinating.

The chain of command should clarify which staff position is responsible for each of these steps. Everyone is responsible for regular, effective communication with other team members and for a calm, deliberate demeanor.

Implement the plans to assess and document conditions and damage and to protect at-risk collections

with the highest priority. For example, this may involve covering collections to prevent further damage or bringing in specialized services for stabilizing temperature and relative humidity. This is one of several response steps for which advance research and planning will significantly increase the speed and efficiency of the response.

Based on the initial assessment of damage, knowledge of the extent and type of collections affected, and the areas of the institution affected, plan the next steps in the response to determine what resources are needed. The initial response should remove (or protect) as much of the collection as possible from imminent danger, and the recovery and salvage plan should slow or stop damage from the agents of deterioration. There is never one clear path that will solve all the salvage issues, so flexibility along with periodic reassessment is essential. Staff should receive advance training in basic methods for handling and salvaging materials to stabilize the objects, with the expectation that expert knowledge will be necessary at points during the recovery to assess the condition of individual objects and guide methods of mitigation.

Reinforce the need for continuing documentation, communication, and coordination among staff, volunteers, and administration. Salvage and recovery plans require flexibility, informed decision making, and revision as work continues. Recognizing that the recovery phase can extend for months, or even years, clear communication with administrators is critical to manage the recovery and obtain adequate resources for the work. Good photographic documentation can help with fundraising efforts as well as supporting insurance claims.

RESOURCES

Print and online references should continue to be updated to provide the most effective information for planning, responding, and recovering from emergencies. Become familiar with resources available through the Heritage Emergency Management Task Force⁴ (HENTF)—cosponsored by FEMA and the Smithsonian Institution (an original member of the task force)—this is a partnership of forty-two national service organizations and federal agencies. Be-

come familiar with the worksheets, fact sheets, and other resources created by or made available by professional organizations committed to collections conservation, and review updated information annually.

Locate practical tools that might help you develop your own plan and training—the American Alliance of Museum’s *Developing a Disaster Preparedness/Emergency Response Plan*,⁵ resources available from American Institute for Conservation,⁶ including worksheets for risk identification and prioritization; videos for salvage response training; the *Field Guide to Emergency Response* (2017 update)⁷ and *Emergency Response and Salvage Wheel*,⁸ and online plans such as dPlan (Northeast Document Conservation Center),⁹ and ArtsReady (ArtsReady.org).¹⁰

The best responses to an emergency are carried out by individuals and organizations that have completed advance research, planning, and repeated training. Resources are available to help, but it is incumbent on the institution to start long before the emergency occurs, and it is the role of the registrar or collections manager to be one of the primary advocates for advance preparations and planning for the safety of the collections. When an emergency occurs, with advance preparations, response team members can implement the plan, confident that they can respond safely and effectively. •

NOTES

1. Available at: <https://www.usgs.gov/mission-areas/natural-hazards>.
2. Available at: <https://www.fema.gov/>.
3. Available at: <https://www.culturalheritage.org/docs/default-source/resources/emergency-resources/repp/repp-risk-prioritization-worksheet.pdf>.
4. Available at: <https://www.fema.gov/media-library/assets/documents/113297>.
5. Available at: <https://www.aam-us.org/wp-content/uploads/2017/12/Developing-a-Disaster-Plan-2018.pdf>.
6. Available at: <https://www.culturalheritage.org/>.
7. Available at: <https://store.culturalheritage.org/site/index.php?app=ecom&ns=prodshow&ref=FAIC-2>.
8. Available at: <https://store.culturalheritage.org/site/index.php?app=ecom&ns=prodshow&ref=FAIC-1>.
9. Available at: <https://www.dplan.org/>.
10. Available at: <https://www.artsready.org/>.

CONTROL OF SOME RISKS to collections will require a variety of security and fire detection and protection systems. In a risk-management framework, these systems are part of the museum's response to block or prevent a threat in advance; in the event that total prevention is not possible, these systems serve to help mitigate the effect of the threat.

Effective policies and procedures implemented by staff are critical to the effectiveness of security and fire-prevention systems. Physical components are essential, but if personnel do not consistently and correctly follow procedures, the physical components can be rendered useless. Although it is beyond the scope of this section to provide extensive descriptions of various systems, it is important to understand the basis for policies, procedures, and equipment for these controls. *Suggested Practices for Museum Security* (rev. 2006)¹ and *Health and Safety for Museum Professionals*² provide recommended practices for security and fire prevention that apply to collections and museums of all sizes

SECURITY

Identify the threats and assess the risks of loss. To safeguard collections, documentation, and associated digital assets from threats of theft and vandalism, evaluate the risks that are relevant to your institution considering its location (geographic region); the external grounds and building site, public areas, exhibit spaces, offices, work spaces, collection storage, and secure collection vault spaces. The process of identifying security risks at each level of possible control applies regardless of the size or location of an institution. With a better understanding of threats, it is possible to determine appropriate means and methods for mitigating the risks; for security threats, those methods include both human (policy, procedure) and equipment components.

Risk control begins with external facility elements—the design of landscaping and outside structures. Comparable digital firewalls need to be assessed for data security to protect electronically stored information from external hacking and vandalism. Collection care staff can identify possible threats by helping facility and security managers understand when and where objects and digital assets might be vulnerable.

At the points of ingress to the museum, whether by the front door or the loading dock, a significant element in a security system is *controlling access*—that is, controlling access and movement of people, parcels, and data. Control of who has the authority to enter and leave the building and individual spaces within the building is essential. Consider where individuals may travel within the building and whether an individual can enter an area unaccompanied or must be in the presence of others. Policies for access need to apply to all levels of staff, trustees, and volunteers as well as contractors, service personnel, and guests; they need to clarify when personnel at each level are permitted to enter and what individuals may or may not carry in and out with them. Procedures should specify how those policies are implemented.

Control of who has access to what types of data is equally essential. Data associated with objects can include information that is sensitive for financial, cultural, ecological, or geographical reasons. As with physical access, access to digital assets needs to be addressed by policy and procedure.

Security equipment can be used to implement access policies (e.g., key controls on a twenty-four-hour clock), to detect events that indicate a failure to follow policies (e.g., intrusion detection systems), and to summon police or guards should such events occur. The equipment is effective, however, only if it supports the policies and procedures and is used consistently and correctly.

In addition to security of the facility, the security of collections in transit (both to and from the museum and within the museum) must be addressed. Establish procedures to review each loan or object transport with respect to security. Consider not only the physical packing parameters but also the chain of custody that might be required; this varies greatly with the method of transport.

Internal security is secured by hiring honest people and by providing deterrence for dishonest behavior. Procedures for achieving these goals include routinely doing fingerprint and background security checks when hiring staff and volunteers. It also involves training to improve awareness among staff and volunteers of the security requirements of the collections and to learn how to handle situations involving potential security breaches. It is important to remember that most museum theft is insider theft.

An effective security system is structured to fit the individual museum, its staff, and its level of resources. Collections care staff advocate for the security of the objects and data, and implement policies and procedures; the director and trustees need to provide an adequate level of resources for equipment and training as part of their fiduciary responsibility for protecting the institution's collections.

The checklist in TABLE 6C.1 enumerates a number of issues to consider when establishing security systems. The chapter in the *National Park Service Museum Handbook*, PART I, "Museum Collections Security and Fire Protection,"³ provides an introduction to security systems based on a risk-assessment approach. In addition to further reading, staff should consult security experts and insurance representatives; both can provide assessments, information, and recommendations directly relevant to the institution.

See also the sample "Museum Incident Report" in the *Collection Forms* section.

FIRE PROTECTION SYSTEMS

Fire safety programs rely on a combination of human and mechanical components. Either one alone is not a sufficient safeguard, and each brings essential ele-

Table 6C.1 Checklist of Issues to Consider for Security System Components

Policies and Procedures
<i>Staff authority for security program</i>
• Staff position responsible for program • Additional positions with collections responsibilities to assist
<i>Access restrictions (who, where, when)</i>
• Who has authority to determine access levels, approve exemptions • Define levels of access for physical spaces • Define levels of access for digital assets
<i>Procedures to allow access</i>
• Key control or password controls • Opening and closing procedures of museum • Opening and closing procedures for individual spaces
<i>Procedures to monitor access</i>
• Sign in and out • Passes • Identification badges
<i>Procedures for inspection of packages (in and out)</i>
• Who and where
<i>Procedures for collections inventories and audits</i>
• Who and when
<i>Emergency response procedures</i>
• Written plan, at least one copy off-site
<i>Procedures for reporting and documenting events</i>
• For theft, vandalism, intrusion, etc. • For events of emergencies, disasters
Staff and Volunteers
<i>Background security checks during hiring process</i>
<i>Formal security staff</i>
• Visible, professional • Contract agency or use in-house staff
<i>Staff training and awareness</i>
<i>Drills for emergency responses</i>
<i>Drills to test security systems and procedures</i>

Equipment
<i>Purpose of equipment</i>
• Intrusion detection
• Tampering detection
• Interruption of building systems (e.g., generators)
• Communication with people to initiate response
<i>Types of contact systems (examples)</i>
• Telephone
• Radio
• Remote monitoring or notification (e.g., text alerts, telephone calls)
<i>Types of detection systems (examples)</i>
• Magnetic contact
• Photo electric ray
• Ultrasonic
• Sound
• Motion
• Infrared
• Weight or pressure
• TV monitor or closed circuit
<i>Maintenance and testing of equipment</i>

ments to the program. The elements of a basic fire safety program include:

- Policies and procedures;
- Staff and volunteer training;
- Equipment selection and location;
- Regular inspections and maintenance; and
- Fire emergency plan.

Policies and procedures set the framework for a fire safety program, establishing who in the institution has primary authority for establishing and implementing the program. Policies clarify responsibilities of other staff positions as well as responsibilities for volunteers. Procedures for fire prevention and safety must identify and address all situations that may pose risks to the collections. For example, workspaces that require scrutiny include exhibit

production, conservation labs, object and specimen preparation labs, research labs, staff and catering kitchen facilities, and building maintenance shops. Functional spaces including public areas, exhibition spaces, programming spaces, and collection storage facilities all need to be assessed. Simply stated, every function and space in the museum is subject to risks from fire; some are merely more vulnerable than others. Staff (and volunteers) involved with each function and space have a universal responsibility to implement procedures for fire prevention as well as have a plan for response to fires.

Staff and volunteer training must be a continuous process to minimize risk from fires and fire damage. Issues for training include:

- How to recognize and correct fire hazards;
- Good housekeeping standards to improve fire prevention efforts;
- Compliance with regulations (e.g., fire doors, use of open flames, smoking, etc.);
- How to store, use, and dispose of flammable and hazardous materials;
- How to notify fire department and museum staff in the event of a fire;
- How to evacuate the building and perform other duties in response to fires;
- Each staff member and volunteer should have hands-on practice using a portable fire extinguisher; and
- General knowledge about automatic sprinkler systems and location of sprinkler heads and control valves.

Sources for training can be found in most communities; your local fire department often has one or more individuals available to provide training for agencies in the region. Fire departments generally welcome opportunities to tour facilities that they might have to protect so as to become familiar with unique aspects of the museum.

Fire protection equipment includes detection systems, signaling (alert) systems, and extinguishing systems. Experts should be consulted to select and locate the most appropriate equipment for the facility, but

collection care staff need to identify particularly vulnerable spaces or objects to be sure these are part of the assessment and design process. Selection of equipment also involves a thorough discussion of the maintenance needs over time because equipment that is not regularly maintained will not respond adequately if an emergency arises.

Detection systems respond to one or more of the following: smoke, heat, sprinkler water flow, or flames. Detection should trigger a signaling system that is monitored continuously by an individual responsible for dispatching appropriate response personnel. The *National Park Service Handbook*, part I, chapter 9, “Museum Fire Protection,” includes a discussion of many types of fire detectors available.

Automatic sprinkler systems are the most common and most effective means of extinguishing a fire (TABLE 6C.2). These are designed so that only those sprinkler heads exposed to heat actually open and discharge water, a factor that limits water damage but suppresses flames. The most reliable and least expensive are wet-pipe sprinkler systems.⁴ Pre-action or dry-pipe systems might be considered for spaces where freezing temperatures are possible. Other, less frequently chosen automatic systems are water mist and gas systems.

Occasionally fire-prevention efforts fail. Thus, it is imperative that the museum have a response plan to mitigate potential damage from fire, smoke, and water. Staff and volunteers need to undergo emergency drills to be comfortable with individual roles and responsibilities. Resources must be available to respond to the crisis (see CHAPTER 6B, “Emergencies: Prepare, Respond, Recover”).

A fire safety program requires a staff that is aware of and trained to prevent and respond to fires. Registrars and collection managers generally do not have the primary responsibility for the safety program, but they should take a risk management approach to mitigate the risks: identify the threats, help develop policies, procedures, and training programs; and regularly implement and assess practices. •

Table 6C.2 Automatic Sprinkler System Descriptions

<i>Wet-pipe</i>
• Water is constantly maintained in the sprinkler pipes. • Generally not used in spaces where the temperature drops below freezing.
<i>Pre-action</i>
• Air maintained in sprinkler pipes initially; water passes through pipes when detector is triggered. • Can be used in spaces where freezing might occur. • Requires functioning fire detection system to operate automatically.
<i>Dry-pipe</i>
• Pressurized air or nitrogen in the direct piping, holding back the water supply at a main dry-pipe valve • Can be used in spaces where temperature falls below 32°F (0°C).
<i>Water mist</i>
• Water in pipes discharged through a valve to make a mist or fog of water.
<i>Gas</i>
• Uses a gaseous agent to extinguish fire either by displacing oxygen or removing heat. • Inert gases include mixtures of nitrogen, argon, and carbon dioxide.

NOTES

1. Available at: http://www.securitycommittee.org/securitycommittee/Guidelines_and_Standards_files/SuggestedPracticesRev06.pdf.

2. C. A. Hawks, M. McCann, K. Makos, L. Goldberg, D. Hinkamp, D. Ertel, and P. Silence, eds., *Health and Safety for Museum Professionals* (New York: Society for the Preservation of Natural History Collections, 2012).

3. Available at: <https://www.nps.gov/museum/publications/MHI/Chap9.pdf>.

4. Canadian Conservation Institute. *Automatic Sprinkler Systems for Museums*, Notes 2/8. updated 2017-09-11. Available at: <https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/canadian-conservation-institute-notes/automatic-sprinkler-systems-museums.htm>.

INTRODUCTION

RISK OF LOSS OR damage to museum objects is a perennial concern for museums. The risk could be a simple accident (such as a ceramic vase falling off a preparator's table), damage due to insufficient protections (such as transit damage), or even an unavoidable disaster (e.g., a flood or severe storm). As custodians of objects, museums must use risk management to recognize, analyze, and control these and many other types of risks. Risks can be avoided, accepted, or transferred. Some risks may be avoided by implementing protective measures (e.g., hire guards). Other risks may have levels of acceptance (e.g., known levels of transit vibration will cause damage to objects over time). Finally, there are risks that can be managed by transferring them to others through the purchase of insurance. Fine art insurance is a risk-transfer mechanism that provides a full or partial financial reimbursement for the physical loss or damage to objects.

Fine art insurance (insurance of museum collections) is purchased through an insurance broker (broker), who is licensed by each state's department of insurance.¹ The broker markets or offers the risk to various specialized underwriters, who work for insurance companies (insurer). The underwriter evaluates the risk, determines the pricing of premiums, and then takes on the risk (e.g., in exchange for the premium, the underwriter agrees to pay out the loss if there is a covered claim). The broker negotiates on the museum's behalf to ensure that the museum (insured) is receiving competitive pricing and coverage. Once the museum gives the broker its approval (bind order) to proceed with the quote, the broker binds the coverage with the underwriter, the insurance policy (policy) is issued, and the insurer is on-risk for the museum based on the policy terms. If there is a loss, the museum reports it to their broker, who notifies the insurer. The insurer appoints a qualified adjuster,

who investigates and settles the loss based on the terms of the policy. Other parties, such as appraisers, conservators, and loss mitigation companies, may be involved in the claim process as well.

REQUEST FOR PROPOSAL PROCESS

When a museum is considering securing or renewing its insurance, the museum staff may decide that it is necessary to formally solicit insurance services from various brokers through a request for proposal (RFP) process. The RFP process gives brokers the opportunity to present to the museum their insurance services, company history and experience, and references. The museum may require oral presentations from the participating brokers and may call the references provided in order to evaluate and select a broker for the museum.

The RFP may include a request for quotation (RFQ) to solicit quotes from all participating brokers. If the RFQ is included in the RFP, the museum may prefer to provide a *market assignment* that requires the brokers to use only an assigned list of insurers. However, it is generally recommended that the RFQ be issued after the museum selects its broker so that the broker will have full and exclusive access to all available markets and be able to negotiate thoroughly on the museum's behalf. Once the museum has established a relationship with its broker, the broker may market the museum's policy to various insurers on an as-needed basis depending on the broker's assessment of changes in insurance market conditions.

POLICY RENEWAL

The museum should review its insurance policy annually as part of a renewal process. Typically, the review begins sixty to ninety days prior to the renewal date (policy expiration date). The broker will request

updated information from the museum, such as the total insurable value (TIV) of the permanent collection and long-term loans at each location; top ten list (the individual values and details of the ten most valuable objects in the permanent collection); a general facility report² for each location; upcoming exhibition schedule with estimated values for each exhibition; and outgoing loans or other risk exposures for which the museum is responsible for insuring while off-site during the upcoming year. Once received, the broker will review the information with the museum and may request additional details. The broker negotiates the renewal with the underwriters for various limit options and presents the renewal quote options to the museum staff, who select the desired coverage level for the upcoming year and advise the broker of its bind order for the renewal. This process must be completed prior to the expiration date of the current policy so that there is no lapse in coverage. The broker will bind the renewal with the underwriter and send the policy to the museum.

INSURANCE COVERAGE BASICS

The insurance policy should cover any object that is in the museum's care, custody, or control, or for which the museum is responsible for insuring. This includes the permanent collection, jointly owned objects, residual or promised gifts, objects on approval for acquisition, long-term loans, and temporary loans. Objects should be defined in the policy's *property insured* clause to include collectible objects of every description, including but not limited to paintings, etchings, drawings, photographs (including their frames, glass, shadow boxes, and vitrines), rare books and manuscripts, numismatic objects, rugs, tapestries, antiques, sculpture, statuary, ceramics, pottery, porcelain, memorabilia, natural history specimens, historical objects, archeological artifacts, video artwork, packing crates, installation and reinstallation material, and technical equipment including video monitors, projectors, electronic data processing hardware and software of a nonartistic value used in association with, or as part of, an exhibit used in direct association with an installation or exhibition, and other bona fide works of art, or rarity, his-

toric value, or artistic merit. The most important wording for the property insured clause is "not limited to" (e.g., the object type does not have to be specifically listed for it to be covered). In this way, the litmus test of *rarity, historic value, or artistic merit* is used to determine policy coverage. Electronic equipment, crates, and other installation material used in connection with the display of objects may be covered under the policy as well.

All-Risk Coverage

The fine art insurance policy is a form of inland marine insurance, derived from the earliest type of insurance available for objects that can be easily transported from one place to another. Inland marine policies can vary greatly by insurer and should be written as *all-risk* policies, such that all risks of physical loss or damage are covered, unless specifically excluded by the policy. In an all-risk policy, it is critical to understand the policy exclusions to be able to grasp the extent of the policy coverage.

Exclusions

Most museum insurance policies have only a few policy exclusions, such as wear and tear; gradual deterioration; inherent vice; loss or damage sustained due to or resulting from repairs, restoration, or retouching process; acts of war, insurrection, rebellion, revolution, civil war; seizure or destruction under quarantine or customs regulations; confiscation by order of any government or public authority; illegal transportation; and nuclear reaction or radiation. Many policies offer terrorism coverage as an option available for an additional premium charge. Depending on the location of the museum, the policy may have coverage restrictions or exclusions relating to earthquake, windstorm, flood, or other catastrophic events.

Valuation

Most museum insurance policies have two main clauses of valuation—valuation of the permanent collection and valuation of property belonging to others (loans). The permanent collection valuation clause should be the purchase price or current market value, whichever is greater. If there is a claim, the loss adjuster will ask the museum to provide docu-

mentation from inventory records regarding the most recent value of the object. At times, the value in the museum's inventory is either outdated or not available. If this is the case, a third-party appraiser will be assigned to appraise the object after the fact, based on the photographs and records that the museum can provide. Although seeking updated appraisals for the entire collection may not be feasible for the museum, it is strongly recommended that the museum obtain regularly updated values on at least the highest valued or most important objects in the collection. It is also a good practice to get an updated value whenever an object is requested for an outgoing loan.

For loans to the museum, the valuation method should be *agreed value*, based on the value provided by the lender on the loan agreement and countersigned by the museum. The museum is not expected to appraise the objects or verify the accuracy of the lender's values. However, if the lender provides a value that is extraordinary, the museum may ask the lender for documentation to validate the value prior to countersigning the agreement. Because the agreed value is the payoff value used in the event of a total loss claim, the values should be realistic and accurate. In all cases, it is important that all objects have an agreed value in the loan agreement and to not leave the value section blank or agree to pay current market value. This helps significantly in the claim process by avoiding possible disputes, which can prolong a claim and cause aggravation to all parties. Loan agreements should be updated and re-signed regularly (avoiding long-term loans) so that the lender's agreed value remains accurate based on current market conditions.

Partial versus Total Loss

When a claim is made, the loss adjuster will determine if the claim is a partial or total loss of the damaged object. In the case of a partial loss, the policy will pay for the costs of repair or restoration and any resulting loss in value after restoration, as agreed between the museum (or lender) and the insurer. In the case of a total loss, the full value of the object is paid by the insurer and the damaged object (called *salvage*) is either destroyed or is transferred to the insurer. The museum may be able to buy back the salvage from the insurer if it believes there is still some merit in

keeping the object in the collection. The policy may include special clauses that allow certain sovereign interests to retain the damaged object even if a total loss is paid, due to the national patrimony and national importance of the object. Check with your broker if you see this requirement in a loan agreement.

Policy Limits

The insurance policy will be written with specific maximum payout limits for losses while the object is on premises, in transit, or at other locations. Usually these limits are written on a per-occurrence basis, meaning that the limit is the most the insurer will pay in any one event or disaster. The museum's limits may be considered *blanket*, and as such, claim payments will be allocated as needed in the event of a catastrophic loss that affects both the permanent collection and loans.

Premises Limit Determination

Insurance must be purchased to cover all loaned objects in the museum's care, custody, or control for which the museum is responsible for insuring. The total value of loans at any given time throughout the year should serve as the baseline for the museum when determining what *policy premises limit* it needs for the coverage year. Beyond this baseline, the museum can determine how much additional coverage it will purchase to protect the permanent collection. The museum limit determination can vary greatly depending on a number of factors, including the spread of total artwork value throughout the building(s), galleries, storage, or off-site locations; the museum's internal risk tolerance level (which may be determined by the board or director); the museum's geographic location and susceptibility to natural catastrophic events (e.g., hurricanes or earthquakes); and the concentration of value in its individual highest valued objects versus the rest of the collection. Although a museum may choose not to purchase a policy limit that reflects its collection's total value, all museums should have an educated and thoughtful means of determining what policy limit they are comfortable with for each policy year. Avoid using a straight percentage of permanent collection total value to determine the policy limit; this method is arbitrary and irresponsible because it

does not account for concentration of value in various locations in the museum or the museum's exhibition schedule.

Museums may determine their policy premises limit by evaluating their probable maximum loss (PML) scenario as defined by the museum administration. The PML is generally defined as the largest loss that could result from a covered disaster (e.g., fire, flood), assuming the normal functioning of protective features (e.g., firewalls, security system) and proper functioning of most (perhaps not all) active suppression systems (e.g., sprinklers). For example, the destruction of a storage vault, a specific high value gallery, or a wing of the museum may be used to estimate PML. When calculating this figure, it is important to remember that all property owned by others for which there is a binding loan agreement (requiring the museum to maintain insurance coverage) will account for the first payment in the event of a catastrophic loss. Examine the PML estimates frequently, especially in times of rapid collection growth, museum construction, volatile markets, or increased exhibition activity. A policy limit sufficient for the museum's PML a decade ago may be absorbed by a single object today.

It may be necessary once or twice a year to increase the policy limits temporarily for a high value incoming exhibition or decrease the policy limits due to a higher value outgoing loan from the permanent collection. Depending on the length of the exhibition or loan, it may make more sense to change the policy limit for the entire coverage year rather than making a short-term change. Review the policy limit with the museum's broker in advance to determine when and how much limit change may be needed.

Transit and Any Other Location Limits

The museum's insurance policy should include a limit on insurance coverage for objects in transit. Examine the museum's transit history and total values by conveyance to determine what transit limit is needed for the coverage year. Typically, insurers will automatically include a transit limit that is a percentage of the premises limit. Similarly, the policy should include a limit for off-premises or any other location coverage. This limit is intended to cover temporary exposure

at other locations that are not listed in the policy. If objects will be at another location for an extended period of time, ask your broker if the location should be added to the policy. Keep your broker updated, especially if the museum is responsible for insuring objects at other locations in high-risk areas (e.g., high-risk seismic zones or coastal areas) because your insurer may have internal underwriting restrictions in those areas and must keep track of total exposure aggregations. As always, a high level of communication and disclosure to your broker is vital. Check the territorial limits of the policy to determine whether the transit and other location coverage is worldwide or restricted to the United States and Canada.

Acceptance of Risk—Objects Belonging to Others That Are in the Museum's Care

When negotiating loans pay close attention to the terms of the loan agreement, particularly regarding the museum's liability and insurance responsibility. Ideally, the insurance section should perfectly align with the museum's insurance coverage and limit the museum's liability to what is paid by insurance. When a loan agreement is signed that holds the museum responsible for any loss or damage, the museum makes itself directly financially liable for losses that may not be covered by its insurance. This is called *absolute liability* and should be avoided. Consult your museum's administrators for a proper course of action if this is required by a potential lender.

If the museum has a high value incoming exhibition, it may be advisable to apply for the US government's Arts and Artifacts Indemnity, which is administered by the National Endowment for the Arts.³ The Indemnity Program was created by congress in 1975 to help minimize the costs of insuring museum exhibitions. The museum must adhere to specific guidelines and protective measures and apply to the program during set application periods. Once approved for the indemnity coverage, the specific objects in the exhibition are covered for physical loss or damage (subject to limited exclusions) by the faith and credit of the US government. Based on the medium of the object, the values submitted, and other factors, the indemnity coverage may be for the full loan agreement value of an object; a value less

than the loan agreement value; or it may not cover specific objects at all. In cases where there is a shortage between indemnity coverage and the exhibition's total value, the museum should use its insurance policy or a separate exhibition insurance policy to cover the difference in value. The museum's policy should also cover the indemnity deductible, which is variable, based on the total indemnified value.

Transfer of Risk—Objects Located Outside of the Museum's Care

When objects are outside of the museum's care, custody, or control, the museum should transfer the risk by either requiring the other party (e.g., the borrower) to insure them or by purchasing a separate exhibition policy. It is most appropriate that the party that has care, custody, or control of the object be the party responsible for insurance. This insurance responsibility should be clearly defined in the loan agreement. Review the borrower's insurance terms carefully and require a *certificate of insurance* prior to the object departing the museum. If the borrower does not have insurance coverage acceptable to you as the lender, require the borrower to pay for a separate exhibition policy to cover the object so that the museum can be assured of sufficient and proper insurance coverage.

In the case of a multiveneue traveling exhibition, it is ideal to purchase a separate *wall-to-wall* exhibition policy that covers the exhibition for the entire tour (during all transits and at all venues). This method of coverage simplifies the insurance so that the lender gets only one certificate of insurance (if requested), ensures that there is no confusion or dispute over who is responsible for insuring at any point in time, and allows the venues to divide the insurance costs according to their respective portions of the tour. However, if this option is not economically feasible, the individual venues may consider providing insurance by using their respective policies to cover their portion of the tour. It is critical that the insurance responsibility for each venue be clearly defined in the exhibition and loan agreements and that the transfer of insurance responsibility takes place at the time of condition reporting on packing or unpacking the objects.

CLAIMS PROCESS

When an unfortunate event occurs and an object is lost or damaged, clear and concise reporting procedures are critical to ensure a smooth claim process. The museum should have on hand the policy's claim reporting form, which will list the pertinent information needed to report a claim to the insurer. Gather the information and put it in writing as soon as possible. Take photographs of the damage, collect environmental data, and record statements from witnesses. Notify the museum's broker by telephone and in writing. The broker will contact the claims representative from the insurer to begin the claim process. In the case of a suspected theft or vandalism, contact the appropriate authorities (e.g., local police, Federal Bureau of Investigation, etc.). Once the claim has been reported, your broker should provide you with the claim number and the name and contact information of the assigned loss adjuster. The loss adjuster will be your main point of contact on the claim. The loss adjuster's role is to investigate the loss, verify coverage according to the policy terms, and recommend a claim settlement to the insurer.

If the nature of the loss is catastrophic (e.g., hurricane, fire), the insurer should be notified as soon as possible so that it can dispatch its loss adjuster immediately to assist with coordination and recovery on site. Because the priority is to contain the loss and prevent further damage, the adjuster may authorize, on behalf of the insurer, funds needed to hire additional security or provide temporary storage or mobile equipment needs, such as portable climate control or freezer units. If immediate action is required to minimize continued destruction, the museum's policy should cover the costs according to the policy terms and limits.

The museum should work closely with the adjuster to make sure that the claim stays on track and is settled properly. If the claim involves an object on loan, allow the adjuster to communicate directly with the lender to expedite communication and claim resolution. Keep in mind that museum object claims can take longer than regular property insurance claims because of the unique nature of the objects. The claim may require the consultation with a living artist due

to the Visual Artists Rights Act (VARA), conservators, or appraisers, depending on the damage. Although these unique elements in a museum insurance claim do take additional time, keep in touch with the adjuster to make sure there is no unnecessary delay.

As with any insurance policy, claims on your museum insurance policy will impact the museum's future premium costs. In particular, underwriters pay close attention to frequency and severity of losses. If a museum has regular and frequent losses or if the museum experiences a major loss, underwriters may require a premium increase, a higher policy deductible, or coverage restrictions. Instead of filing a claim, the museum may decide to absorb the conservation or repair costs internally. Discuss this with your broker since it is always better to err on the side of disclosure rather than potentially risking claim declination due to late reporting (i.e., in the event that it is later determined that a claim does, in fact, need to be filed). If a claim is filed, the museum should be able to withdraw it at any point without jeopardizing the museum's loss history. The museum should closely guard and protect its loss history—not just for the interest of preservation of the objects, but also to help minimize insurance costs going forward.

CONCLUSION

Museums can successfully transfer their risks to their permanent collection and temporary loans through the purchase of fine art insurance. This unique insurance is flexible and requires the specialized oversight of the museum's insurance broker, who is the museum's advocate. Critical to the success of the museum's insurance program is thorough and proper documentation—from inventory records to loan agreements, condition reports, and exhibition schedule tracking—and a close relationship with the museum's insurance broker. Once coverage has been obtained and agreements have been signed, the museum staff can rest easy, knowing that if a loss or damage occurs, the museum will be protected.

Insurance Terminology

Additional insured. A person or entity not included in the *named insured* on an insurance policy, who is added to the policy at the request of the named in-

sured. The policy may state that owners of objects on loan are automatically listed as *additional insureds* as their respective interests may appear. On most insurance policies, the rights and responsibilities of the additional insured are generally not defined so the term's impact may be unclear. The term is more appropriately found and defined in a general liability policy.

Arbitration. A policy clause that can be triggered if the museum and the insurer do not agree on the amount of the claim settlement. The process is a clear and fair method of resolution that typically involves three appraisers—one representing each party and, if needed, a third umpire appraiser selected by the two chosen appraisers. The decision determined by the appraiser parties in the arbitration process is final.

Bailment agreements. A collector lending an object to a museum may have a financial loan in which the object is used as collateral. When this occurs, the financial lender may require the museum to sign a *bailment agreement* whereby the financial lender makes certain requirements of the museum with respect to access to the object, procedures for collateral collection (if needed due to loan default by the owner), and other conditions. From an insurance perspective, it is important that the museum ensure that the bailment agreement consistently refers back to the loan agreement (e.g., regarding the agreed insurance value of the object) and that it limits the museum's liability to what is covered by its insurance.

Cancellation. All insurance policies should include a cancellation provision that allows the insured or the insurer to cancel the policy subject to given conditions and notification requirements. Because most states have laws regarding specific insurance cancellation notification requirements, review your policy for specific terms and conditions.

Certificate of Insurance (COI). A certificate of insurance is a snapshot of the insurance policy currently in force that is used to verify the coverage for a specific object or loan. Certificates do not change the coverage on the policy, they only attest to the existence of coverage at the time of issuance. The issuance of certificates is not required for coverage to be in place for loans under a museum's pol-

icy. However, if you are a lending institution, you should request a COI from the borrowing institution to verify proper insurance coverage.

Currency fluctuation. An insurance clause that allows coverage to be applicable to loans in foreign currency. The conversion date should be specified as the date of claim settlement so that foreign lenders are paid appropriately in their country's currency when the claim is settled and the funds are transferred.

Deductible. The amount paid out-of-pocket by the museum before the insurer will pay any expenses under a covered claim. Often in museum fine art insurance policies, the deductible only applies to losses affecting the permanent collection while on premises. It is ideal for the deductible not to apply to losses affecting loans so that the museum itself does not have to make any payments out-of-pocket for covered damages to loaned objects.

Duties of the insured. A clause whereby the museum is required by the policy to use the best professional judgment and practices in protecting the object. Carefully review the policy to see if it includes any coverage warranties or conditions that may restrict or void coverage if the museum is not in compliance. If you are reviewing a borrower's policy, confirm that the borrower will comply with all policy warranties or ask that the warranties be removed.

Endorsements. Formal changes to an insurance policy. Endorsements may adjust the limits, modify coverage conditions or locations, or make other alterations, either temporarily or permanently, to the policy. Always retain policy endorsement documents in your insurance files.

Fraud or misrepresentation. Policy coverage is voided when there is intentional lying or concealment by the named insured (e.g., the museum), whether regarding material facts about the museum (e.g., past claims history or application details) or a claim. Note that fraud differs from employee dishonesty. In the case of employee dishonesty, the employees are acting on their own behalf and for their own interests and not the interest of the museum. Employee dishonesty is typically covered under a fine art insurance policy, but fraud is never covered under any insurance contract.

General liability. Insurance coverage that protects the museum from a variety of claims from others—including bodily injury, property damage, and personal injury—that can arise from the museum's business operations. For example, if a visitor slips and falls at the museum and sues the museum, the museum would turn to its general liability insurance policy to cover the visitor's medical expenses, etc. Lenders might require proof of general liability coverage from the museum if loaned objects or an installation could cause injury to a visitor (e.g., an interactive and immersive exhibit installation). In this case, it is appropriate to require the general liability COI to list the lender as additional insured so that the general liability coverage extends to the lender in the event of a claim. General liability coverage is a separate insurance policy from the museum's fine art insurance.

Gross negligence/Willful misconduct. The intentional failure to perform a manifest duty and a reckless failure to exercise ordinary care. Gross negligence and willful misconduct are both legal terms and determined by a court of law. Typically, fine art insurance policies do not exclude them. You may encounter these terms in a policy subrogation clause whereby the insurer may pursue responsible third parties if there is proof of gross negligence or willful misconduct. In this case, the terms do not impact policy coverage itself; they only impact whether the insurers may subrogate after a paid loss.

Immunity from seizure. The legal guarantee that cultural objects on temporary loan from another country will be protected against seizure during the loan period. Many countries have regulatory procedures for applying for immunity from seizure and lenders may require this to be completed prior to agreeing to loan an object. Note that seizure of an object is generally not covered by a museum insurance policy. However, separate government confiscation/seizure insurance policies are available to cover this risk.

Legal liability. A policy coverage for the museum should it be legally pursued to pay for a loss to a loaned object for which the museum was instructed not to insure (e.g., the lender elected to maintain its own insurance coverage rather than allow the

museum to insure); the policy would cover the legal costs incurred to defend the museum in this case. The best defense against these types of claims is a fully executed loan agreement that includes a clearly defined insurance responsibility clause and that has been signed by representatives of both the borrower and the lender.

Limits of liability. The maximum amount to be paid in any one loss. Limits are defined on the declarations page of the policy for coverage on premises, at any other location, and in any one conveyance while in transit. Limits will be for the total costs of a claim, whether for a partial or total loss, salvage fees, or other covered expenses.

Loss buy-back. The policy provision by which the museum may choose to purchase a recovered object following a paid theft claim for it. If a total loss has been paid for an object, the object belongs to the insurer according to the terms of the policy. However, by this provision, the museum may purchase the recovered object from the insurer. Typically, the museum pays back the same amount that it received from the claim, plus loss adjustment and recovery expenses. Some policies include an interest charge as well, whereas others may require the current market value of the object to be the buy-back price. This clause varies from policy to policy.

Loss payee. A person or entity named in the policy that is entitled to all or part of the insurance proceeds in connection with a specific object for which it has a financial interest. It is appropriate to request that the owner of an object be listed as loss payee on the certificate of insurance. In a museum insurance policy, owners of the objects on loan are often automatically considered to be loss payees as their respective interests may appear.

Other insurance. A policy clause that states that should another policy or national indemnity coverage be in effect at the time of the loss, the policy may limit payment to the amount of excess or amount not paid by the other insurer.

Pairs and sets. A policy clause that addresses whether an object is a part of a pair or set of objects. The policy may allow for full payment of the entire set if there is damage or loss to a part of the set and the insured does not wish to keep the remaining parts.

In that case, the remaining parts are surrendered to the insurer. It is important that pairs or sets are clearly described and noted as such on the inventory records or the loan agreement with the value reflecting the total value of the set.

Subrogation/Recourse. The right for an insurer to legally pursue a third party who may have caused loss or damage to an object. Subrogation is done after a claim has been settled and paid. Successful subrogation can result in lowering the claim on the insured's loss history, so allowing your insurer to subrogate other parties is helpful to the museum. However, shippers or storage facilities might require a *waiver of subrogation* so that the museum's insurer is not able to pursue subrogation against them in the event of a loss. This waiver protection can be invalidated in cases of gross negligence or criminal activity, which would be determined by the court of law.

Wall to Wall or Nail to Nail. A common museum term that implies that coverage for the loaned object begins at the moment it is removed from the wall or the collection storage array at the lender's location, with coverage continuing through packing, transit, unpacking, installation at the borrowing museum, deinstallation, repacking, transit, and concludes on return to the wall or the collection storage array at the lender's location. Coverage is, therefore, in effect from the first instant the object is touched by the packers or handlers until the loan is officially terminated. Loan termination should be in writing, preferably by written receipt, and should note that the owner has accepted the object's condition as it was returned. A critical element for well-defined wall-to-wall insurance responsibility is thorough condition reports and photographs of the object at the very beginning and at the end of the loan period. •

NOTES

1. Insurance Information Institute. Available at: <https://www.iii.org/>.
2. *General Facility Report*, American Alliance of Museums, 2011. Available at: <https://ww2.aam-us.org/ProductCatalog/Product?ID=891>.
3. Available at: <https://www.arts.gov/artistic-fields/museums/arts-and-artifacts-indemnity-program-international-indemnity>.



FIGURE 6E.1 PESTS. CREATED BY VERNE J. ANDERSON.

THE GOALS OF this chapter are to:

- Introduce the concept of integrated pest management;
- Provide a deeper understanding of what pests are;
- Help staff of museums, historic houses, and archives develop sustainable strategies to manage museum pests; and
- Provide resources to further learn about integrated pest management.

This chapter provides a starting point for developing an integrated pest management plan and putting it into practice in your institution. There is much that is not covered here but there are resources listed at the end of this chapter that will help.

Pest Scenario

A collections technician opens a cabinet and watches in horror as a beetle strolls across a no-pest strip that had been placed in the drawer to protect the bird study skins inside. One of the study skins was shuddering. It was full of

larvae, munching away. The pesticide strip had no effect on pests.

Sound familiar? In the past, the standard way to address any infestation was to use poison or call in an exterminator (who used poison). This would solve the immediate problem, but the infestation would eventually reoccur, so poison would be applied again, and so on, and so forth—often leaving a concentration of poisons. Yet the infestation would return. In some cases, such as the one described, the pest population would build up a tolerance to pesticide. This was obviously the wrong approach. It was at that time that new ways to approach the challenge of pests were explored.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a holistic approach to reduce pest activity using a combination of methods, including environmental management, cultural actions, and reduction of pesticides. This systematic approach is dependent on a variety of strategies to reduce the presence of pests, including pest identification, environmental control, building maintenance, and improved housekeeping. There is a reliance on regular and ongoing monitoring just to make sure that a new infestation has not appeared. If there is a new infestation, then it is caught before it becomes a disaster. These methods are more environmentally sustainable than previous, pesticide dependent methods.

Traditional pest control depends heavily on the use of pesticides. In museum collections, heavy metal pesticides, including arsenic, lead, and mercury, were historically used to protect objects sensitive to infestation. Taxidermists seem to have had their own formulas using arsenic soaps and other chemicals;

these soaps were usually painted on the interior of the skins prior to mounting. During the first half of the twentieth century, neurotoxins and other organic compounds were developed, including DDT. These proved to be highly effective pesticides with increasingly worrisome side effects, both in terms of human health and the health of our planet.

IPM, as a term, was first used in the 1970s to describe less toxic methods being used to control agricultural pests, with an emphasis on integrating pest biology and cultural practices. In the early 1980s, an IPM approach began to be explored for nonagricultural needs. The National Park Service adopted IPM as the standard for pest management relating to both museum collections and to invasive species in the parks.¹ IPM is now the accepted way to manage pests in museums, and elsewhere.

Why Use IPM?

Pest Scenario

1980. The collections are stored in a basement room that flooded over a long weekend. The water has been drained, and the space is dry again, all of the cabinets are opened to air out. A pest management company is sent in to fumigate as a preventive measure against the possibility of infestation. Once the treatment is completed, the curator sends a researcher to storage to examine the most sensitive textile collections. A clothing moth is seen fluttering about. The source—an Inuit child's caribou parka—is discovered under a plastic bag. It is literally shimmering with adult clothes moths and larvae. The fumigation failed to solve the problem and the parka was damaged beyond saving.

Moral of the story: reliance on pesticides to deal with pest problems may not work. This is only one reason why collections care professionals use IPM methodology. To begin with, the history of pest control is the history of poisons. The chemicals used are effective in killing not only the targeted pest but are also detrimental to human health and to the health of the environment, as detailed in Rachel Carson's 1962 book, *Silent Spring*. Many of the chemicals used

in common pesticides remain as residues on the collection objects and in the spaces that were treated with them. A good example is mothballs. If you can smell that distinctive mothball odor you are inhaling toxic fumes. The active ingredient in most mothballs is either naphthalene or paradichlorobenzene (PDB). Technically, naphthalene is a repellent, meaning that it will discourage moths (or other pests) from eating anything around it, but it does not kill. PDB, on the other hand, is a pesticide—a neurotoxin—it kills. Naphthalene is flammable. Its effect on human health includes anemia through damage to red blood cells, dermatitis, sinus infections, fatigue, nausea, vomiting, and potentially several types of cancer. It has been banned in the European Union since 2008. PDB is less flammable and has mostly replaced naphthalene as the active ingredient in mothballs, air fresheners, disinfectants, and urinal cakes. It also is a suspected cancer causing chemical, with health effects similar to naphthalene. It is poorly soluble in water and does not break down in the ground, so it remains present in the environment. This smell is added to mothballs as a warning that there is a potentially dangerous chemical present, so that we detect it before it becomes hazardous. Not only are these chemicals bad for us, but they can be bad for the collection. They can add contaminants, cause fading, or other deterioration. PDB, for example, is a benzene ring combined with chlorine. In high enough concentrations it will cause fading.

By employing IPM methods we concentrate our efforts on using biological and cultural means to reduce infestations (see BOX 6E.1, "Definitions"). We

BOX 6E.1 DEFINITIONS

Biological methods—Understanding the biology and life cycle of the pest. This leads to an understanding of why it is present, what it is eating, and what environment it prefers.

Cultural methods—What we can do to reduce (or eliminate) the threat to collections (and us) from the pest. Methods include repairing holes in the building fabric, improving housekeeping, reducing attractants such as food, water, and light, thus eliminating the reasons why the pest is there.

look for the source of the pests and address the reason as to why they are there, rather than simply applying pesticides again and again and waiting for a reoccurrence. This multipronged approach is much more effective in reducing infestations and is better for the preservation of the collection.

Legalities

Many, if not most of the pesticides that were available to museums in the past are now listed as controlled substances and can no longer be purchased or used. Pesticides are highly regulated, and for good reasons; they are environmentally detrimental, causing serious damage to the biodiversity of the planet. Once used, many remain in the environment for a long time, causing significant collateral damage.²

There are state and federal laws governing the use and application of pesticides that include what chemicals can be used in public facilities such as museums or schools, who should apply them, and under what circumstances. For example, mothballs are no longer registered for use in museums. Mothballs can still be purchased over the counter at hardware and grocery stores, and they can be used in the home—just not in the museum. Other pesticides are registered but must be applied by a certified pest management professional (PMP). Pesticides can be used, and sometimes need to be used, but they should never be the first choice of a defense against an infestation. Always check to confirm that the pesticide used in the institution or on the grounds is registered and is properly applied.

How to Move Forward

The goal is to get rid of the pests. But how? Our toolbox is significantly reduced if we no longer can legally or ethically use pesticides. The Canadian Conservation Institute (CCI) has developed a tool to identify and reduce the risks of damage to collections, called the *Framework for Preserving Heritage Collections*.³ Ten factors or agents of deterioration have been widely acknowledged by the conservation field, one of which is pests (the others are physical damage, thieves and vandals, dissociation, fire, water, contaminants, light, incorrect temperature, and incorrect relative humidity).⁴ The agents are listed here because they interact with each other and can

be used to help control infestations. This tool identifies three levels at which the risks can be addressed—the building level, the local level, and the procedures level. Finally, five strategies are used to address the risks—avoid, block, detect, mitigate, and recover or treat the damaged object. This framework provides a practical and systematic method for addressing risks. It is a logic model designed to develop control strategies that are adaptable to any given situation or institution. The tool will be referred to throughout this chapter and provides an excellent problem-solving method for dealing with pests.

Another important resource is the Museum Pest Network.⁵ This is a website, originally developed by the Society for the Preservation of Natural History Collections, designed to provide much-needed resources for pest problems. The site is meant to be a one-stop spot for information that a museum professional facing a pest challenge needs. Subjects covered include monitoring techniques, pest identifications, and treatment options. There are also additional resources and a link to join the Museum Pest Network List.

A successful integrated pest management program has six steps (see FIGURE 6E.2):

1. Monitoring.
2. Identification.
3. Solutions.
4. Prevention.
5. Treatment.
6. Evaluation and revision.

Monitoring will tell you what pests are present and leads to identification. Identifying the pests will inform the solutions that you choose to deal with them. Solutions will include a combination of exclusion (avoiding and blocking egress), improved housekeeping, and reduction of food and habitat. Treatment and recovery will reduce or remove the (hopefully) dead pests from the area and objects in the collection. Finally, you must evaluate the strategies to determine their effectiveness and revise procedures as necessary. If this last step is ignored, then it is likely that the problem will occur again. Documentation of processes, treatments, and findings is

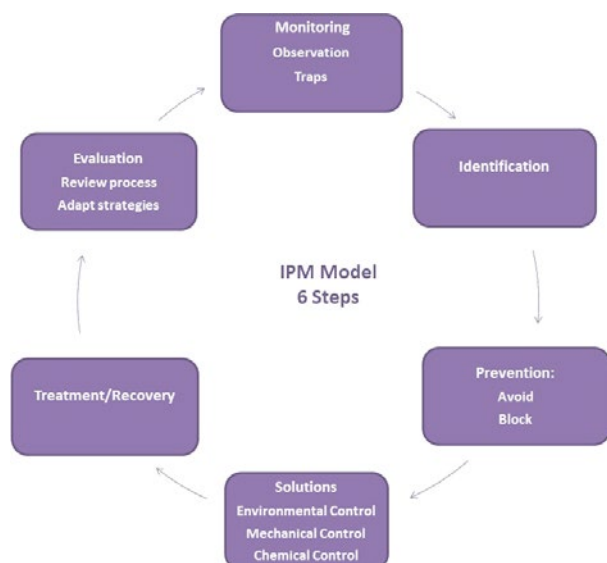


FIGURE 6E.2 THE SIX STAGES OF AN INTEGRATED PEST MANAGEMENT (IPM) PROGRAM ARE CYCLICAL. CREATED BY GRETCHEN ANDERSON.

mandatory for evaluation. You do not want to repeat the same mistakes.

Pest Identification and Risks

It is important to identify which pests specifically pose a threat to the collection. Once the pests are identified, you can make more effective decisions on how to deal with them by learning what the pests eat, how they live, what kind of environment they thrive in. With this information about their biology, we can determine why they are in the museum or historic house, and we can put our limited resources into the most cost-effective and sustainable way to meet the challenge. This is at the center of a successful IPM program.

What Is a Museum Pest?

Pests are animals and plants that come into conflict with humans. In the context of museums, archives, and historic houses, we usually mean insects, vertebrates (animals with backbones), and mold. Not all insects or vertebrates are pests. For example, there are more than a million species of insects and the clear majority are not classified as pests. The primary species we are most concerned with cause direct or indirect damage to our collections. This narrows the pool of suspicious (bad) actors even more. Some pest species are irritants; others cause serious damage, or

human health issues. The focus of the following section is specifically on museum pests—what they are, why they are present, and what we, as collection care professionals, can do about them.

Pest damage to your collection will depend on many factors, beginning with what materials your collection is composed of. For example, if the collection is primarily paper-based, then any museum pest that eats or uses cellulose (paper) or sizing will be of primary concern, including silverfish, cockroaches, and mice (there are more; this list is not complete). Silverfish and cockroaches will graze on the surface, eating the sizing as well as the paper itself. Mice and rats will happily shred paper to make their nests. This is where understanding the basic biology and the habits of the pest species helps the collection care specialist determine why the pest is present and develop sustainable strategies to reduce the impact pests have on the collection.

Understanding Pests

Pest Scenario

Collection staff report small bugs in storage and panic ensues. The staff fear an infestation. A sample is taken to an entomologist and identified as ground beetles, which live outdoors in leaf litter. Ground beetles will not survive long inside the building, nor will they cause direct damage to the collection. The danger is that they will provide a food source for actual museum pests. We call these casual invaders. The solution: check for holes in the building fabric and block them. Clean the space to make sure that most of the beetles are gone. But do not panic!

Is the creature that is in the museum a pest or a casual visitor? Has it set up residence or is it just wandering through? The answers to these and similar questions will help to determine how to address the situation in the most efficient and cost-effective manner.

The first step is to identify the potential pest (e.g., insect, rodent, etc.), to name it. This will help determine if it is a casual invader or one that will cause damage. Once you know its name, knowledge of its life habits (e.g., what it likes to eat, how it likes to live, where it nests, how it breeds) can be determined. Only

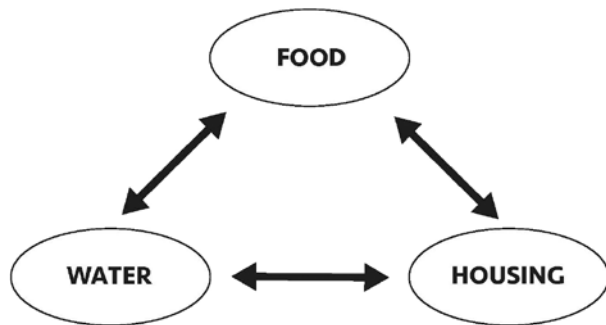


FIGURE 6E.3 ALL PESTS NEED THREE THINGS FOR SURVIVAL: FOOD, WATER, AND A HOME. CREATED BY GRETCHEN J. ANDERSON.

then can a strategy for dealing with it be built. IPM uses the biology and life habits to eliminate the risk.

IPM does not have to be too complicated. One pest control professional put it this way. There are three things that all living organisms need: food, water, and a place to live (home). If you can eliminate access to just one of these attractants, it will be easier to eliminate or reduce pest presence (FIGURE 6E.3). It is important to learn a little bit about the biology of the pests that invade your institution because the more you know, the easier it will be to find the most efficient and cost-effective way to protect the collection.

What Is in a Name?

Names can be confusing. Common or regional names are often misleading. For example, the pocket gopher (a northern US name for a specific rodent) is

known as a salamander in some places in the southern United States. This is confusing because salamanders are the common name of a specific type of amphibian. Another example—have you ever heard of a palmetto bug or flying water bug? These are regional (and less pejorative) names for the American cockroach (*Periplaneta americana*), which is the large (1.5-inch-long) reddish-brown cockroach that is omnipresent throughout the United States. It originated in tropical Africa and has made its home here. It is not the same as the black native species of cockroaches, most of whom thrive outside of the urban environment. In situations like this the scientific name will clarify the animal or plant that is being discussed. Scientific names are not that hard, once you know the system (see BOX 6E.2). The scientific name is the formal name identifying a specific species, removing the ambiguity in common names. Understanding the scientific name will help communication with pest control consultants. Scientific names are written in italics, with the first word capitalized and the second lowercase. Scientific names reflect the hierarchy of biological classification. Consider the common house mouse, *Mus musculus*. The first word, *Mus* (which is the Latin word for mouse) is the genus, the second word, *musculus* (which means dim or dark, in reference to the color of the house mouse) is the species name. Only one species is referred to as *Mus musculus*, and that species has specific physical and behavioral characteristics (such as preferred

BOX 6E.2 BIOLOGICAL CLASSIFICATION

Biologists classify organisms by how similar they are to each other in a hierarchical system using Latinized names. The higher up the hierarchy of names, the broader the relationships; the lower down the hierarchy, the closer the relationships between species. When using integrated pest management (IPM) in the museum and other cultural settings, the focus is usually on the genus and species names, but often information can best be found using these in combination with the family name. For example, for purposes of identifying a museum pest, you might need to know that the American cockroach in the storage area is *Periplaneta americana*, but when looking for information about its habits, it is useful to know that it is in the family Blattidae. Here is how this looks in the hierarchy of biological classification:

Kingdom Animalia
 Phylum Arthropoda
 Class Insecta
 Order Blattodea
 Family Blattidae
 Genus *Periplaneta*
 Species *americana*

environment or food) not shared by other types of mice. If several species in a genus or an unknown species is referred to, the abbreviation “sp.” is used; thus, you could refer to any species of mouse in the genus *Mus* by writing the name as *Mus* sp.

What Are the Pests?

There are three basic categories of pest species:

1. Arthropods (which includes insects, spiders, and centipedes);
2. Vertebrates (e.g., mice, rats, pigeons, squirrels); and
3. Mold (a fungus that grows on surfaces, often causing staining and structural damage).

Insects

Insects are the most pervasive and numerous museum pests. They are the hardest to find because they are small and often go unnoticed until the damage has been done. All insects are arthropods (which means “jointed foot”). All arthropods are invertebrates, meaning they have an external skeleton (exoskeleton), rather than an internal one like mammals or birds. There are many thousands of insect species, living under diverse environmental conditions, but all insects have six legs, and most have wings. Only a limited number of insects are classified as museum pests, and they are not the only arthropod commonly found in the museum. Spiders, centipedes, springtails, and others may be present. Pay attention to these because they may be pests or incidentals or an indicator of the presence of pest species. For example, spiders and centipedes hunt insects, so if you see them in a storage area, it is an indication that there are probably insect pests in the collection; a spider’s web can indicate where insect pests are living or gaining access to the collection.

There are two types of insect life cycles to be aware of—complete and incomplete metamorphosis. Species with *complete metamorphosis* deposit eggs, which hatch into larvae. The larvae undergo multiple molts as they grow and shed their exoskeletons, and then form pupae or cocoons from which they emerge as adult beetles, moths, flies, etc. In these species, the larval stage is the most voracious (hence,

the stage we are most concerned about) and in fact some adults, such as clothes moths, do not even feed. Species with *incomplete metamorphosis* have a different life cycle. Their eggs hatch into nymphs, which generally look like small versions of the adults. The nymphs go through several molts (the intermediate stages are called *instars*) until they become adults. These insects eat throughout their life, so all of the stages may cause damage to collections. Cockroaches and silverfish are examples of insects with incomplete metamorphosis.

Cultural heritage pests are often subdivided into categories based on their food preferences:

1. Protein feeders such as dermestid beetles and clothes moths;
2. Pantry pests such as grain moths and grain beetles;
3. General feeders such as cockroaches, silverfish, and booklice; and
4. Wood feeders such as powderpost beetles and termites.

Identify the Insect Pest

Insects can be identified at any life stage. You will most commonly see either the adults, the larvae, or nymphs, but you might also find tiny dried droppings or feces, called *frass*⁶ that can sometimes be used to identify pests. See BOX 6E.3 for a summary of the most common insect pests.

Protein Feeders

These are beetles and moths that exclusively feed on fur, feather, wool, leather, horn, and silk—anything that is made of protein. Collections made of these materials are at risk, including textiles, taxidermy mounts, many ethnographic objects, study skins, and horsehair furniture stuffing. The specific habits of protein feeders are species dependent. Most of the damage they do is caused by the larvae, who have voracious appetites, and the larvae may remain in the feeding mode for several years, depending on the species and environmental conditions. The adults of some protein feeders, such moths, do not feed at all. On the other hand, adult beetles (commonly called

Box 6E.3 INSECT PESTS

Protein feeders—Beetles and moths that go through complete metamorphosis. Among the common species to watch out for are:

Dermestids

- Carpet beetles (*Anthrenus* sp.)
- Fur beetles (*Attagenus* sp.)
- Hide beetles (*Dermestes* sp.)
- Odd beetle (*Thylodria contractus*)

Moths

- Webbing clothes moths (*Tineola bisselliella*)
- Case-making clothes moths (*Tinea pellionella*)

Pantry Pests—Insects with complete metamorphosis

- Drugstore beetles (*Stegobium paniceum*) eat starchy plant material, dried foods, plant specimens, and dried animal skins.
- Cigarette beetles (*Lasioderma sericorne*) feed on dried food, dried tobacco, plant specimens, and dried animal specimens.
- Grain beetles (*Oryzaephilus surinamensis*) feed on dried foods and grains. There are a number of related species (Family: Silvanidae) including the saw-toothed grain beetle.

General feeders—Insects with incomplete metamorphosis

- Cockroaches (*Periplaneta* sp.) feed on almost any food. There is a wide variety of roaches, from all over the world, but the most damaging species in museums are the oriental, German, and American cockroaches.
- Silverfish (*Lepisma* sp.) require high humidity and are often found in basements and under sinks. A related species, the firebrat (*Thermophila furnorum*) is more at home in hot dry climates. Both feed on starch and paper-based objects, often grazing on the surface and eating the finishes on the paper.
- Psocids (*Liposcelis bostrychophila*), commonly known as *booklice*, feed on mold. Their presence is an indication that humidity levels are too high (above 68 percent) and that microscopic mold is present. When feeding on the mold, they can damage paper.

Wood feeders—Most insects in this category go through complete metamorphosis, with the exception of termites.

- Furniture beetles (*Anobium punctatum*)
- Powderpost beetles (*Lyctus* sp.)
- Carpenter ants (*Camponotus* sp.)
- Carpenter bees (*Xylocopa* sp.)
- Deathwatch beetles (*Xestobium rufovillosum*)
- Termites (*Isoptera* sp.) often live in huge colonies that extend for miles. Complete destruction of the colony is not practical, so localized treatments are usually recommended.

dermestids) will continue to cause damage, burrowing into cardboard or wood to lay eggs. Each species has its own preferred environmental conditions. Most dermestids like warm and humid conditions, but moths tend to prefer a drier environment. Most protein feeders like dark, still areas, although some are attracted to bright colors and the light when they are adults.

Dermestids are easily identified. The larvae are generally torpedo-shaped with tufts of bristles in seg-

ments of the body. They are generally 0.5–10 mm long, depending on the species and the molt. The adults are round or oval, about 2–5 mm long, depending on species. They can fly, but are most often seen crawling. Colors vary in both the larvae and the adults, depending on the species. Some will burrow into wood or cardboard to pupate. The most interesting is the odd beetle (*Thylodria contractus*), which have larvae that are orange and curl into a C-shape if threatened. The adults are sexually dimorphic,

meaning the male and female are physically different in appearance. The males look like small flies and fly well. The females look like the larvae, have vestigial wings, and do not fly.

Clothes moths are small and plain looking. The adults do not fly well, avoid light, and do not eat. The larvae of both common clothes moth species are white and soft-bodied, with dark heads. The case-making clothes moth larvae create cocoons out of the material they are feeding on and their frass, thus camouflaging it as part of whatever they are eating.

Pantry Pests

Pantry pests, also known as *stored product pests*, generally eat dried and processed food products. Food sources range from flour, corn meal, and spices to crackers, nuts, and dried fruits. Beetles, moths, and ants are common pantry pests. These pests may be found in unexpected places in storage, such as in animal skins. In one case, it was discovered that a technician was using corn meal to absorb fluids while skinning animals—a perfect food for grain beetles.

General Feeders

The general feeders eat protein, mold, starch, and paper. Archives, herbaria (botanical collections), any paper-based objects or documents, and dried foods are susceptible to these pests. They may graze on the surface of paper or feathers, or burrow into an object leaving holes and tunnels. The larvae may chew their way into wood or paper products to pupate (FIGURE 6E.4).

Wood Feeders

These insects will eat or nest in wood. Carpenter ants and carpenter bees prefer moist, soft, rotting wood; most termites and deathwatch beetles prefer dried dead wood and can digest food fiber. Some wood feeders make tunnels, but the presence of tunnels in a wooden object does not necessarily mean there is an infestation because most insects that live in live wood evacuate or die as soon as the wood is dead. Although we are not particularly concerned about species that live in live wood, it is important to keep in mind that they do leave tunnels, particularly between the bark and the wood.



FIGURE 6E.4 COCKROACH. CREATED BY VERNE J. ANDERSON.

Vertebrates

Vertebrates are generally easier to spot and to deal with than insects. Rodents (mice and rats) are the most ubiquitous, but birds, squirrels, and bats can also be a concern. Most are looking for a place to live, perhaps overwinter, or maybe just something to eat. Food is the main attractant for mice. The most practical way to deal with a vertebrate problem is to learn about the habits of the animal and block its access to the building or space.

Vertebrates will cause serious damage to the building and collections. Mice and rats chew constantly because their teeth continue to grow throughout their life. They urinate as they move along walls to mark their path and territory. Mice constantly forage for food and get most of their water from what they eat. In colder climates they often come inside

buildings to get out of the cold. Once a house mouse is inside it will stay if there is food and a place to nest.

The house mouse is thought to have originated in Central Asia and has spread throughout the world by hitching rides with humans. They are territorial and rarely travel more than thirty feet from their nests. House mice are prolific; females reach sexual maturity in forty-two days and live for an average of one year. They produce an average litter of six and can have up to seven litters per year, producing up to forty-four offspring during this time.

Mice are smart, curious, and sociable. They can get through openings as small as 1/4 inch; if they can fit their head through a crack or crevice, they will squeeze their body through as well. Mice are attracted to human food and love chocolate (FIGURE 6E.5).

Rats are larger than mice and can be identified by their hairless tails. There are fifty-six species of rats. The black rat or house rat (*Rattus rattus*) and the Norwegian rat or brown rat (*Rattus norvegicus*) are the ones we are most familiar with and the ones known to spread diseases to humans. Like the house mouse, most rat species are invasive and have spread through-



FIGURE 6E.5 PEST INFESTATION. CREATED BY VERNE J. ANDERSON.

out the world, wherever humans live. They are attracted to human food and can cause a great deal of damage through chewing, defiling, and nesting.

Birds

By nesting in attics and roosting on roofs, birds can cause a great deal of damage. Their droppings are acidic and will cause staining and aggravate corrosion on metal and can pose human health issues. Their nests are the natural habitat for clothes moths and dermestid beetles (which keep the birds' nests clean by eating cast-off feathers and dried food).

Bats

Bats are generally looking for a place to live if they enter a building. Under the eaves or in the attic are ideal places for them to rear young and overwinter. Although bats may have a bad reputation through folklore, they are considered environmentally beneficial because of their main food sources (mosquitos and other insects) and many species are endangered through loss of habitat and contamination. However, bat guano is acidic, and like all mammals bats may carry rabies and must be dealt with carefully.⁷

Mold

We have all dealt with mold at one point or another. Mold is a fungus that spreads through spores, which are found in the air almost everywhere. Under the right environmental conditions, mold will grow on almost any surface. Favorable conditions for mold growth usually mean relative humidity levels above 68 percent for a period of forty-eight hours or more. Mold can cause staining and structural damage to the object it is growing on, and several mold species are known to be toxic to humans. It is advisable to get the mold identified by an expert and wear personal protective equipment when dealing with it.⁸

Monitoring Strategies

To deal with a pest infestation, the first step is to identify the problem. You might see an insect flying, or a mouse scampering across the floor. You might notice that there are holes in a blanket or see tell-tale webbing on an object. A combination of observation

and the use of traps is the best way to gather information about the pests that are present. Observation alone does not provide the complete picture—only what might be seen in a given instance. Traps provide a more complete picture of pest activity that includes around-the-clock information (what is caught or seen). The data (the pest species that are observed and trapped) should be carefully documented. These records provide information about what specific pests and occasional visitors are present, when they are likely to be seen, where they are concentrated, and where they are coming from. The documentation should include the date of the sighting (or date when the traps were checked), location of the observation or trap, the species seen, and the number of each type of pest. Systematic monitoring is the best way to gather the data needed to develop a strategy to reduce the risk to your collection.

The trap type will depend on your situation. Most of the traps discussed here are used for indoor situations, although there are traps designed for outdoor pests as well. Other types of traps may be more appropriate for your situation. Keep in mind that traps will not kill an entire population. They are used to monitor activity and show what species are present, but traps alone cannot prevent an infestation from occurring.

For most insect species, *blunder traps* are the most commonly used trap. These are also known as sticky traps or glue boards and consist of a piece of paper coated with a sticky substance. As they move about, the pests stumble on to the traps and stick to the surface. There are several inexpensive brands that are commercially available through pest management companies and hardware stores. The most common type of sticky trap is sold as a flat sheet that can be folded to form a tent or a box shape, which helps to keep dust off the adhesive. Homemade blunder traps can be made with double-sided tape placed on paper, with duct tape, or by an application of a material called Tanglefoot™. Sticky traps should be placed in out-of-the-way areas, along the junction of the floor with the wall, next to doors or windows, in cabinets, and next to (but not touching) objects. Blunder traps should be checked regularly, and the insects caught on them identified and counted. When a lot of in-

sects are stuck to a trap, it should be replaced; a heavily loaded trap is no longer effective as a trap and may become an attractant for pests that feed on the bodies of the insects stuck on the trap. When used inside of cabinets or drawers, care must be taken not to place sticky traps where objects other than pests can become stuck to them.

Pheromone traps are available for some insect species. These consist of a sticky trap with a pheromone lure—a chemical attractant that draws the males of a specific species to the trap. Pheromone traps are available for some of the more common species such as clothes moths and pantry pests but must be placed with care because they can attract males from the outdoors into the building. Pheromone traps are significantly more expensive than blunder traps.

Light Traps are useful for many insects, such as fruit flies, that are attracted to light, particularly ultraviolet light. Light traps are usually metal boxes that contain an ultraviolet lamp and have a sticky trap in the bottom. The insects fly into the light, die, and fall onto the sticky trap. Light traps are effective and are often used in kitchens and near garbage areas. It may be necessary to clean the area around light traps frequently as not all of the insects fall on the sticky trap, and ultraviolet light traps should not be placed where the light can shine on collection objects.

The best way to monitor mice and rats is with *snap traps*, which are the most effective and least cruel of all rodent traps. With a snap trap, the rodent is almost always immediately killed when it jostles the trigger.

There are several reasons why poison should not be used for rodents. Most rodent poisons (called *rodenticides*) are anticoagulants, combined with a food bait. The mouse or rat nibbles on the bait and goes back to its nest where it slowly bleeds to death, which is inhumane. The dead body, hidden away in the nest, then becomes a food source for dermestid beetles and other pests. The poisoned bait may also be infested with grain beetles or moths.

The use of glue boards for rodents is problematic because the rodent caught on the trap dies slowly of dehydration and may drag the trap away and die in hiding. When this happens, it creates the added problem of the dead mouse or rat becoming the attractant for dermestid beetles, starting a new pest

problem. Snap traps should not be set in public areas where children can get into them. When using snap traps, set them perpendicularly against a wall, with the trigger facing the wall. Mice and rats run along walls for protection and will be more likely to trigger the trap if it is positioned properly.

Live animal traps are commonly used in public areas or loading docks where snap traps are likely to be set off by vibrations. Live traps are metal boxes with entrances that the rodent can get into, but cannot get out of. Live traps must be checked frequently because trapped mice can die of dehydration within a day. I once found that a female mouse had given birth to her babies in the trap, and all had died. Remember that mice and rats are territorial and if released outside the building, they are unlikely to survive but might come right back indoors. Live traps are useful for larger pests such as squirrels and racoons. Once trapped these animals must be relocated away from the museum.

Mitigation Strategies

A gallery staff member notices a small moth fluttering toward a painting and contacts the registrar. Panic ensues (FIGURE 6E.6).

This sort of situation is what the CCI *Framework for Preserving Heritage Collections* is designed for! Once the pest has been identified, the framework can be used to help develop mitigation strategies. Examine the three levels (e.g., building, local, and procedures) at which to act and the five strategies that you can use (e.g., avoid, block, detect, mitigate, and recover).

Avoid—Can you avoid the situation? How do you avoid it? This is where you begin to apply your knowledge of the pest because if you know what attracts the pest you might be able to avoid creating a habitat that attracts it. For example, this might mean creating a sanitary perimeter around the building because mice will be hesitant to cross a three-foot space with no clutter for hiding as it leaves them exposed to predators. For mice, a sanitary perimeter might mean a three-foot-wide and two-foot-deep span of cement or rock, which they will be hesitant to cross and unlikely to tunnel underneath to reach the building.

Other landscaping choices will significantly help to reduce flying insects from entering the building:



FIGURE 6E.6 DO NOT PANIC; THERE IS A SOLUTION. IT MAY TAKE WORK AND TIME, BUT THE SOLUTION CAN BE FOUND. CREATED BY VERNE J. ANDERSON.

- Choose plants that do not attract unwanted pests (i.e., adult dermestid beetles are attracted to white flowers).
- Keep plantings away from doors and windows, trim trees so that they do not come close to the roof or exterior walls. When this simple step was taken at one museum, an ongoing carpenter ant problem was eliminated.
- Grade the ground around the building so that water flows away from the building. This will reduce mold growth from moisture moving through the foundation.
- Improve drainage by adding French drains to redirect surface water.

Avoiding pests inside the building can be done as well. If the building has interior environmental control, can it be set to discourage pests from moving

in? If this can be done and the desired environment would not damage the building, then it is worth exploring. Regulating the internal environment can be done at either the building level or the local level. Use dehumidifiers and fans to better manage humidity, being careful not to create additional problems. If a dehumidifier is used, make sure that it is regularly emptied or automatically empties into a drain. An improved and controlled environment will also enhance the condition of all collections along with helping to prevent pests.

Natural history museums usually have very large collections that are susceptible to moth and dermestid infestations, which can devastate organic materials and destroy both exhibition and research specimens. If the museum has the resources, these collections can be kept cool (60°F), with stable relative humidity (45 ± 5 percent). Pests will be unlikely to want to set up shop, no matter how tasty the objects are. This is a local solution specifically for storage because it is too cold for staff, researchers, or visitors.

Block—There is a lot that can be done to block pests from entering the building or gaining access to collections. At the building level, overall good building maintenance is mandatory. Remember that the building is the first line of defense to protect the collection and, in the case of a historic house or structure, it is the collection. Make it hard for the mice to get in; look for holes into the building, especially near the ground level, and block holes in the attic and roof. This will keep squirrels, bats, raccoons and birds out. Work with a PMP to determine when the best season is to seal these holes because you do not want to close the animals inside an attic. Remove bird nests from the eaves and attics to reduce clothes moths and dermestids. Other common strategies at the building level are common sense:

- Use screens on windows and doors.
- Maintain exterior surfaces in good repair (keep wood painted, replace deteriorating mortar for brick and stone). One museum was able to eliminate a mold infestation by repairing the mortar; the infestation was discovered before it became a major issue due to the identification of minute in-

sects, which ate mold and were discovered through monitoring.

- Seal holes and cracks in the exterior walls to prevent water from coming in.
- Maintain the roof in good condition.

Eliminate sources of standing water in places such as elevator shafts, along exterior walls, and in basement mechanical rooms. Make sure that the rooms adjacent to collection storage are dry and clean. Use storage cabinets and display cases that are well sealed, especially for objects that are sensitive to pest damage.

Housekeeping, as a standard operating procedure, is a vital strategy to be used in combination with other strategies. Go back to what the pests need—food, water, and a place to live. If the museum reduces clutter and is kept clean it will be easier to find the pests and will make it more pleasant for the staff and visitors. This means establishing responsibilities for who does the cleaning, what needs to be cleaned, and how often—in other words, a housekeeping plan. Do not forget the hidden, less-trafficked areas, which are often where the most pests will be found. The plan should be reasonable according to resources (FIGURE 6E.7).

The importance of managing food cannot be overstated. Food is one of the main attractants for pests that come into the building. Establish clear rules about where human food is allowed and not allowed, and whether food may be prepared on the premises (FIGURE 6E.8). Create a food management plan that works for the institution (see BOX 6E.4) but reduces the potential of infestations (the food management plan should be closely linked to the housekeeping plan). Isolate trash bins and dumpsters or move them away from the building. One large urban museum solved a rat problem by enclosing the trash dock.

A set of written procedures should be developed for live plants in the building. In an ideal world, live plants or cut flowers should not be allowed in the museum because they increase the likelihood of attracting insect pests. However, if plants are permitted, make sure that they are healthy and well cared for. Live plants should be closely monitored for pests



FIGURE 6E.7 HOUSEKEEPING. CREATED BY VERNE J. ANDERSON.



FIGURE 6E.8 FOOD IN THE MUSEUM. CREATED BY VERNE J. ANDERSON.

Box 6E.4 FOOD MANAGEMENT

Important elements of a food management plan include:

- Make sure that kitchens and designated eating areas are kept clean.
 - Check drains—keep them clean and keep the traps filled with water.
 - Stove and preparation areas are notoriously hard to clean, but extra effort should be made.
 - Do not allow food or garbage to stay in the building overnight.
- Use covered garbage cans and keep them clean. This will significantly reduce feeding and breeding grounds for fruit flies and other insects associated with garbage.
- Determine under what circumstances (if any) food and drink should be allowed in the galleries for special events and set strict standards for cleaning up immediately after the event. Although it is ideal that no food ever be allowed in the museum, it is understood that food at special events is often necessary.
- If your historic house or museum has a food-based educational program, develop procedures to make sure that the foodstuffs are maintained in such a way as to eliminate pantry pests. This might include defining the type of containers that dry goods (e.g., flour, sugar) are kept in or that dry goods be kept in a refrigerator or freezer.
- Determine where staff and volunteers should eat and where they can store their lunches.

(in one situation, live tropical plants were being used by a family of mice as their nesting spot!). Cut flowers may brighten a space but can also bring in pests and can cause water damage while being maintained. Take extra care to avoid damaging historic furniture if live plants are used; it is preferable to use silk flowers and plants instead because they will not attract pests. Avoid the use of wild flowers or flowers from the garden, if possible. If real flowers are mandated, use greenhouse flowers from a facility that uses systemic pesticides when growing the plants as these will be less likely to host unwanted insects.

Finally, keep monitoring, as it is an ongoing process. The only way to find out if the strategies you are engaging in are working is to be vigilant. If the methods are not as successful as you wish, then adapt. Go back to the beginning and tweak what is being done.

The best and least toxic method to deal with insects, mice, and mold is a combination of all these techniques:

1. Monitor to determine where the pests are getting into the building;
2. Block the access points in the building; and
3. Improve housekeeping and clean up any dead animals, nesting spots, or debris left behind.

Use monitoring (with snap traps) and observation to track animal movements, and remember that they move three-dimensionally, climbing wires and pipes. Eliminate all access to food and improve housekeeping, and continue to trap; this is the one instance in which a monitoring method is also key to eliminating the pest.

Pest Scenario

An intern was doing an object check in a collections storage room in the basement of a museum. He noticed white fuzz growing on some African masks. Concerned, he called the conservator and described what he was seeing. The conservator dashed down to storage to confirm his fear. Indeed, all the wooden and hide objects in two rooms were covered in mold. The rooms were located on an outside wall that had no vapor barrier or insula-

tion. Everything was removed from the rooms and mechanically cleaned. The rooms were washed with a bleach mixture and the block walls painted with a fungicidal paint used on the interior of barns. Cabinets and shelving were thoroughly cleaned. A small heating, ventilation, and air-conditioning (HVAC) unit was installed for the entire storage area. Collections were returned to the space, reorganized, inventoried and a regular monitoring program initiated. Cabinets were moved away from the outer wall to allow for greater airflow, which was about 95 percent effective. A few years later, very small spots of mold were found in one space in the corner, which was a dead area with no airflow. Fans were added to improve the airflow and that did the trick.

Treatment Strategies

The steps in treatment are straightforward, and are as follows:

1. Isolate and examine.
2. Treat objects, storage furniture, and rooms.
3. Clean objects and storage spaces.
4. Clean and examine.

When a potential infestation is discovered, it is time to take action. Both the space where the infestation is found and the objects need to be treated. As discussed, the traditional approach of indiscriminately using general poisons is not advised and is often illegal, so what are the other options? For spaces, rooms, and cabinets, housekeeping is the answer. Clean out the cracks and crevices with a high efficiency particulate air (HEPA) vacuum. A HEPA vacuum removes minute (2.5 micron) particles and contains them in a bag. Follow vacuuming with soap and water treatment using a soft scrub brush; its old fashioned, but it works. If mold is a problem, seek the advice of a mold remediation specialist. Check the spaces for holes, cracks, and other egress and address those issues. Make sure that the space is thoroughly cleaned and dried prior to returning collections.

Isolation—When an infestation is discovered, the first thing to do is to carefully isolate and exam-

ine the infested objects. Determine if the infestation is active (alive) or not (old, dead). If it is not active, remove the frass, clean the object, and continue isolation to ensure that the pests do not return. Do not return the object to storage or exhibition until you are sure that the infestation is no longer active. If the pest infestation persists, decide how to treat it. Activity should be carried out away from the main collection, so that there is less possibility of spreading the infestation to other objects.

It is best to have an isolation room as far away from collections as possible. Use it for objects that are entering the building, either new donations, or new or returning loans. Examine all objects carefully before incorporating them in collection storage or exhibitions. Many infestations have been spread through the exchange or loan of objects among museums. In fact, it has been documented that the odd beetle, which originated in Asia, has been spread worldwide by the exchange of museum objects, particularly herbarium specimens.

Be creative with isolation methods. There is never enough space. At one museum with a serious dermestid infestation and absolutely no space for a permanent isolation room for examination and isolation, the registrar and IPM technician came up with the idea of using a tent, the sort that might be used to keep mosquitos away from a picnic. It was completely self-contained, with extremely small mesh screenings. The tent could be set up anywhere as needed, even in the middle of a collection storage space. This meant that objects of concern could be brought into the space and examined without fear of exposing other objects and the tent could be completely cleaned out, even dry cleaned if necessary, when the project was done.

Treatment choice will depend on several factors. The first is what materials are the objects made of, and whether they might be damaged by the treatment. Several commonly used treatments will be briefly described, but for the most up-to-date information and more detailed procedures, check the Museum Pest Network solutions tab.⁹

Thermal treatment can be one of two types, either low temperature (freezing) or high temperature. Both are well-researched and are the safest methods

BOX 6E.5 PROCEDURES FOR FREEZING COLLECTIONS

- The infested object should be bagged in two layers of plastic, with as much air removed as possible. This prevents ice buildup on the object, eliminates the possibility of condensation damaging the object, and reduces fluctuation of equilibrium moisture content. Each layer of plastic should be well sealed.
- When the object is removed from the freezer it should be allowed to come up to room temperature before being unwrapped (allow at least twenty-four hours before opening the plastic bags).
- After treatment, the object should remain in isolation for at least two weeks to make sure the treatment was successful.

for killing insect infestations. Low temperature has been used for museum collections since the 1980s, and when done correctly, it has an excellent kill rate and will not damage most objects (see BOX 6E.5). The goal is to quickly freeze an object so that the pests in it will die. All life stages (adults, pupae, larvae, nymphs, and eggs) must be killed. The critical temperature is -22°F .¹⁰ The length of time needed for freezing to be effective depends on the object. For small objects or specimens (e.g., pinned insects), seventy-two hours is usually sufficient. For larger objects a longer time is required.

Of course, there are several types of objects that should not be frozen, including paintings on canvas, many audiovisual materials, wax, glass, and damp plant material. However, the method is so safe that some institutions use freezing as a preventive measure when moving large quantities of collections from one place to another.

Heat treatment is also successful and easily done. Research has shown that the critical temperature for killing insects (adults and eggs) is 130°F with a short exposure time. The equipment outlay can be simple and inexpensive. There are several strategies described on the Museum Pest Network website including using an oven, a heater, and fan, or a black bag in the sun. However, there are several caveats. Any material that is subject to damage at 130°F should not be treated with heat (e.g., waxes and resins). Care must be taken to not

dry out the object, which will cause damage; the best way to prevent dehydration is to double-bag the object. There are some other methods described on the Museum Pest Network site that also work.

Controlled atmosphere treatments—The key feature of controlled atmosphere treatments (CAT) is the elimination of breathable oxygen. In essence, the insect dies through suffocation or dehydration. There are three primary methods for CAT in use in museums:

1. Carbon dioxide (CO₂),
2. Inert gas (nitrogen or argon), and
3. Oxygen scavenging.

The setup for all three methods is similar. An air-tight container is needed, as any leaks in the container will reduce the effectiveness of the treatment. With CO₂ or inert gas, a vacuum is drawn to purge the container of breathable air. At the same time the CO₂ or inert gas fills the container. The relative humidity of the gas needs to be regulated so that the objects inside do not desiccate.

CO₂ treatment is considered safe for all objects. The initial expense is considerable because there are specialized systems required (called CO₂ bubbles), which are commercially available, and special equipment to monitor CO₂ levels. Local regulations need to be checked to determine whether a pesticide license is required. Treatment time is four weeks. Large mass treatments can be performed. Further information can be found at Museum Pest Network.¹¹

Inert gas treatment is also considered safe for most objects, except for some mineral pigments, such as cinnabar and sienna, because these pigments can undergo a color transformation in the absence of oxygen. Like CO₂ treatment, these require an outlay for materials and monitoring equipment. Unlike CO₂ these gasses are not regulated as pesticides, so no license is required. More detailed description and product information is found at Museum Pest Network.¹² Treatment time varies slightly for each of these methods but is generally two to six weeks.

The easiest CAT method to use is the oxygen scavenging treatment. An oxygen scavenger (a material that absorbs oxygen from the air) is inserted into a con-

tainer with the infested object. The container is sealed and left for twenty-one days. Inside the container the scavenger absorbs oxygen and the pests die. There is no need to adjust the relative humidity. The biggest challenge is to create an air-tight container. Instructions for this are on the Museum Pest Network website.¹³ This treatment can be used for almost anything with exception of the pigment Prussian Blue. Oxygen scavengers are not a registered pesticide, so no licensing is required. There are several special materials required, which are not absurdly expensive, but can add up, and large quantities of the scavenger are needed. The oxygen scavenger can only be used for one treatment and must be discarded after use.

Insect growth regulators (IGR) are synthetic pesticides that mimic certain insect hormones. They slow or halt an insect's growth and break the cycle of breeding, hence knocking down the population. IGR, like other treatments must be used in partnership with other IPM actions. For example, a natural history institution discovered a serious infestation of drugstore beetles in its storage area. The beetles were drilling into study skins to pupate. The conservator and collection manager worked with a pest management company specializing in museums to use IGR technology as part of the overall holistic strategy to eliminate the beetle. The IGRs were used to slow insect breeding while the collection was processed through low temperature treatment. At the same time the facilities maintenance department found the egress point—an unused boiler on the roof, directly above storage, that was the beetles' primary habitat. There were holes in the roof providing access to the room below. The boiler was removed, and the holes repaired. The cabinets were elevated above the floor on posts so that the floor was completely visible. The entire room and all cabinets were thoroughly cleaned, and housekeeping was improved. Ultraviolet light traps with sticky boards were placed in strategic places in storage. The monthly count of how many insects were caught on the traps went from a serious infestation to an occasional beetle being found.

Chemical Pesticide Treatments—There still is a role for pesticide treatments in museums, but they should never be used directly on collection objects but rather on the building. Localized applications

of pesticides in cracks and crevices will help block insect pests from coming into the building or moving around once inside. These are residual treatments that normally are effective for about two weeks, unless the dust is washed away. If an occasional silverfish is found, an IPM professional might use a gel or powder containing diatomaceous earth to deal with the problem—as the silverfish crawls over this abrasive material the insect's exoskeleton is scratched causing it to die from dehydration.

Contracting with Pest Management Professionals

Many of the methods described in this chapter can be done in house, but there are times when it is necessary to bring in a PMP. For example, if termites threaten, then IGR or other chemical treatments will be required. Any time a registered pesticide is being used in a public institution a licensed PMP does the application. A trained PMP can be an important part of an IPM plan.

When contracting with a PMP it is important to understand what IPM is and how it relates to the institution. Define the goals and do the research. The PMP that you are seeking must have training and experience in IPM. Look at the PMP's website and interview them for the position. Ask questions and get references. Make sure that the company is registered with the National Pest Management Association (NPMA) and any state organizations, and that they are properly licensed. A good PMP, who understands the need of the institution, is a major asset. Once the decision has been made, work with the PMP on a plan to move forward, both with the immediate infestation and with ongoing monitoring.

THE IPM PLAN

An IPM plan is a roadmap for how to proceed to achieve the desired result. It should be relevant to the needs of the institution and the collection. It should be practical and achievable. It is a process that will evolve. It is necessary to check the efficacy of the IPM plan over time, refining it as you become more familiar with the potential and actual pests and conditions at your specific institution. Although IPM procedures can be practiced without a plan, a good



FIGURE 6E.9 IT IS IMPORTANT TO DEVELOP A PLAN AND TO SHARE IT. CREATED BY VERNE J. ANDERSON.

plan will put your actions into context, and help the staff and administration to see how everything fits together. This will help to communicate the priorities and justify expenses.

There are four key stages in developing an IPM plan:¹⁴

1. Recognizing and identifying priorities for action.
2. Identifying responsible staff.
3. Acting on high priorities.
4. Establishing procedures for future planning, financing, and review.

The procedures set the standards for how to go about the specific actions and treatments, describe best practices, and explain detailed actions that are to be followed to achieve the aim. They are training and reference tools, which provide consistency.

Sharing the Pain—Institutional Collaboration

Facing an infestation and building an IPM program can be overwhelming, so it is important to build collaborations to develop a team who can help. Look across the institution for roles that are natural fits for the team. Facilities and operations staff should



FIGURE 6E.10 INTEGRATED PEST MANAGEMENT (IPM) WORKS BEST WITH A TEAM. BETTER IDEAS AND STRATEGIES ARE DEVELOPED THROUGH EDUCATION AND COMMUNICATION. CREATED BY VERNE J. ANDERSON.

be among your closest allies because they encounter pests, both dead and alive, on a regular basis, and so are vital to monitoring threats. Food services and special events staff deal with one of the major attractants—food—so they need to be involved. Education and frontline staff should also be included as well because they are the ones who are out in the public and see things that other staff may not. Collection staff who deal with pest risks on a regular basis are also important to include. Finally, administration and finance need to know what is going on.

Use the infestation and the IPM plan to educate your colleagues about the importance of IPM. People often find pests disgusting and gross. Use that to your advantage, empower the staff to help you with the solutions. Most often, the staff will be delighted to help get rid of the pests. Enlist the entire staff in helping to monitor by establishing a pest reporting system (paper or electronic, whichever works). Educate the staff as to what can be done without the use of pesticide and emphasize that IPM is more sustainable and environmentally friendly than the traditional methods of dealing with pest problems. Create an IPM team of key staff, making sure to include facilities staff. The more educated about pests and the building the team is, the better the chances that the solution will work.

CONCLUSION

An IPM program is a work in progress (BOX 6E.6). It is the way to gain control of the situation. It will take time, commitment, and a team effort. It will take accepting that you will never eliminate all the infestations that threaten your collection, but by working through this process, you will have a better idea of what risks your collection is facing and what to do about it.

By addressing the pest problem through holistic methods, many of the other risks to collections will also be reduced. All the actions taken to help avoid and block pests, better management of environmental conditions, and enhanced housekeeping, will improve conditions for the collections as well. Each institution is different and will require adaptations of the IPM principles. Solutions will depend on specific situations and must be determined by institutional mandate. A historic house museum, with a historic garden or natural landscape will find different challenges and solutions than an art museum in an urban

BOX 6E.6 PESTS, CLIMATE CHANGE, AND SUSTAINABLE PRACTICES

Climate Change

- Changes in the species, distribution, and number of pests will occur as regional climates change.

Sustainable Practices

- Make sure that traveling exhibitions are pest free to avoid the introduction of invasive species.
- Reduce the use of chemical pest control by using an integrated pest management (IPM) approach with an emphasis on prevention and targeted responses to pests.
- Consider using sanitation; thermal control with cold (−20 to −30°C) or heat (55°C); or controlled atmosphere (CO₂ or N₂) before resorting to chemical control.
- Note that although reducing the use of air-conditioning saves energy, raising interior temperatures will increase the risk and rate of growth of insect infestations.

Source: Canadian Conservation Institute (CCI). *Framework for Preserving Heritage Collections: Strategies for Avoiding or Reducing Damage*, revised. Ontario, Canada: CCI, 1994.



FIGURE 6E.11 NO PESTS. CREATED BY VERNE J. ANDERSON.

setting. What is important is that IPM is a holistic system that can be creatively adapted to any cultural institution to reduce the presence of pests. •

RESOURCES

The following are books, articles, and web-based resources that are helpful when faced with an infestation. Note that a few older publications are listed which, although good for identification and basic information, include recommendations for pesticide treatments that are no longer considered appropriate. Always check the Museum Pest Network for the most up-to-date options.

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Useful IPM Web Resources

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8. Available at: https://www.si.edu/mci/english/learn_more/taking_care/mnm.html (accessed August 25, 2019) and <https://www.nps.gov/museum/publications/consveogram/03-04.pdf> (accessed August 25, 2019).

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13. Available at: <https://museumpests.net/solutions-oxygen-scavenger-treatment/> (accessed August 25, 2019).

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6F | REGISTRARS AND SUSTAINABILITY

LEA FOSTER WARDEN AND SARA FRANZ (UPDATED AND EDITED BY TONI M. KISER)

At first people refuse to believe that a strange new thing can be done. Then they begin to hope it can be done. Then they see it can be done. Then it is done and all the world wonders why it was not done centuries ago.

—Frances Hodgson Burnett¹

REGISTRARS ARE uniquely positioned to take a leadership role in fostering sustainable behavior both within their institutions and in the profession at large. First, registrars are trained to analyze and address actions that may affect the preservation of collections. Their awareness of the connections between behavior and its intentional and unintentional consequences is a vital resource for understanding and implementing sustainable practices. Second, the purview of a registrar's job is vast. Duties span many departments, requiring efficient communication and collaboration. Registrars' relationships with colleagues allow them to approach an interdepartmental project with a broad point of view, an attribute complementary to the sustainability paradigm. As detail-oriented, collaborative decision makers, registrars have the potential to increase the sustainability of their institutions.

To engage in a dialog regarding sustainability, the terms *green* and *sustainable* must be defined. In reference to the environment, the notions of *green* and *sustainable* share a similar objective—to protect and conserve natural resources. *Green* generally refers to an end result (e.g., does this product or action have a benign or positive effect on the environment), whereas *sustainability* reviews an entire system and the relationship between systems (a more holistic approach). One concise definition of *sustainable* is meeting the needs of the present without compromising the ability of future generations to meet their needs.² An action is rated based on whether it maintains an amicable balance among its economic, social, and environmental components—a triple-

weighted scale. Therefore, a product may be *green* but ultimately not *sustainable*. Biodegradable plastic, for example, can be considered green because it degrades under certain conditions relatively safely, but it is not sustainable because more fossil fuels are consumed to manufacture biodegradable plastic than traditional polymers. *Green* products or actions are a step in the right direction, but *sustainability* is the ultimate goal.

Sustainability has become relevant within the framework of climate change. Climate change is the result of humanity's perspective that nature should be dominated or controlled. The Industrial Revolution, for example, was based on a perceived endless supply of "natural capital" and "neither the health of natural systems, nor an awareness of their delicacy, complexity, and interconnectedness, [were] part of the industrial design agenda."³ Humans have spanned the globe, building structures and using resources at a faster rate than can be replenished. Furthermore, the loss of natural habitat coupled with species extinction continues to occur at a rapid pace. The stress that humans have placed on our fragile ecosphere is alarming. Museums play a role in this natural resource drain; standard museum operations such as the maintenance of stable microclimates and exhibitions do impact the environment.

There is growing support, both nationally and internationally, for sustainable initiatives within the museum profession. First, a number of publications are available that discuss museums and sustainability in the areas of outreach, education, exhibit design, lighting, collections care, and food service. Important resources include *The Green Museum: A Primer on Environmental Practice* by Sarah Brophy and Elizabeth Wylie and *Sustainable Preservation Practices for Managing Storage Environments* from the Image Permanence Institute.⁴ Second, it is now routine for museum conferences to include some element of environmental responsibility both in program content

as well as event administration. At the 2008 American Association of Museums meeting, 102 people signed up for the newly formed professional interest committee, PIC Green, now the Environmental and Climate Professional Network.⁵ There are now a number of online resources such as the Sustainable Design Wiki,⁶ the Green Museum Wiki,⁷ the Green Building Wiki,⁸ and GreenExhibits.org.⁹

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

Building green museums is perhaps the best-known initiative within the profession. Green building methods originating from the design and engineering fields are being adopted for the construction and renovation of museums and exhibits. Many museums are also seeking LEED certification.¹⁰ The LEED program was developed by the US Green Building Council to promote design and construction practices that reduce the industry's negative environmental impact and establish guidelines for those practices. One subset of the program is LEED for Existing Buildings and Spaces Operations and Management (LEED-EB O&M).¹¹ This program is designed to implement sustainable operations and maintenance practices to reduce the environmental impact of existing buildings and specifically addresses sustainable sites (including storm water management and light pollution reduction), water efficiency, energy and atmosphere (including indoor environmental quality and energy performance), materials and resources (including purchasing policy and waste performance), and indoor environmental quality (including green cleaning and integrated pest management).¹²

Green Committees

Creating a green committee that uses LEED-EB O&M guidelines is an excellent starting point to implement sustainable operations at a museum—even if certification is not an objective. However, it is important to tailor initiatives to the specific institution in question. In *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*, Doug McKenzie-Mohr and William Smith provide insightful strategies for instituting behavioral changes.¹³ The

authors note the importance of determining the barriers and benefits of a particular sustainable behavior. Because noncommunal, drastic alterations typically do not result in long-term change, establishing an open forum within a museum, in which sustainability goals are defined and potential barriers and benefits are explored, is vital to accomplish successful behavioral changes. Staff members will have varying opinions and knowledge levels about today's environmental problems, and it is important to establish an atmosphere of respect and collaboration.

The opportunity to take a leadership role in forming a green committee is ideal for the registrar given the interdepartmental nature of the position. A green committee will be most successful with the participation and collaboration of all departments. The committee's responsibility may include rethinking current needs, systems, and methodologies, and setting future goals and pathways to achieve those goals. Potential results of a Green Team include economic savings, diminished use of resources (including water and electricity), the formation of mutually beneficial partnerships with service providers, a reduction in museum consumption and waste, and improved standing among constituents and colleagues.

Registrars will find useful information in the aforementioned resources concerning energy efficient technologies and green consumer products to help launch green committee initiatives. However, much work is still needed both to consolidate and to build on data specifically geared for the registration department. Further research into new products and procedures, such as green archival products and alternative lighting strategies, is needed to develop new standards. Opportunities abound for museum studies students and established professionals alike to research and collaborate with service providers to develop, test, and apply alternative methods and materials. The following discussion, therefore, should be seen as one installment in a portfolio the authors believe will continually develop as museums bring their behaviors more in line with environmental sustainability. The topics included range from complex undertakings such as modifying lighting and climate control systems, to more mundane tasks such as the purchasing office paper.

As previously noted, several museums are now building green and seeking LEED certification. One key component of LEED certification is the installation of, or upgrade to, energy-efficient lighting and climate-control systems. The guidelines also promote the use of natural light and passive ventilation as ways to reduce energy consumption. Although these ideals do not completely conform to the standards of object preservation, there are ways to mix passive systems and energy-efficient technologies to reduce a museum's energy consumption.

Lighting

Electric lighting accounts for more than a third of all electricity consumed for commercial use in the United States.¹⁴ Encouragingly, “due to soaring electricity prices and ever-growing environmental concerns about energy consumption and waste disposal, lighting is experiencing a technology revolution.”¹⁵ Museums' challenge with lighting has always been controlling the negative effects of light on objects, which must be exposed to light to be viewed, yet light damage is cumulative and cannot be reversed (see CHAPTER 51, “Preventive Care”).

For many decades, museums have used primarily halogen or metal halide track lighting in galleries and fluorescent lighting in collection storage areas, all of which require filtering to eliminate ultraviolet (UV) radiation. Many types of filtering materials are available to protect objects from light damage, but it should be noted that the shelf life of filtering materials varies from manufacturer to manufacturer. The museum lighting paradigm is now changing, based on advances in lighting technology and the growing need to control the cost of lighting. The following presents four lighting alternatives: LED, fiber optics, hybrid solar, and diffused natural light.

Light emitting diodes (LED) are the most promising new light source with application for museum setting. LEDs consume one-fifth of energy of an incandescent bulb but last one hundred times longer. LEDs are illuminated by the movement of electrons in a semi-conductor material, which is typically aluminum-gallium arsenide. As the electrons move, photons are released—the most basic units of light. LEDs can be used in place of incandescent lights and

can be dimmed without changing the color of light that is emitted—unlike incandescent lights, which become more yellow when dimmed. Although replacing incandescent lighting with LED lighting is expensive, the low-energy usage of LEDs makes them a cost-effective alternative in the long term. LEDs also produce no UV and little heat, which makes them ideal for illuminating objects.¹⁶ LED lighting systems have steadily improved over the last twenty years and are now widely used in museums.

Fiber-optic lighting, also known as *remote source lighting*, uses plastic or glass fibers to distribute light. The fibers can be side emitting, which means the fiber itself is lighted, or end emitting, which means the light is conducted to an attachment at the end of the fiber. The benefit to using fiber optics, as noted by the Center at Rensselaer Polytechnic Institute, is that locating “the light source outside of a secured enclosure, such as a display case of costly objects, means the display area doesn't have to be opened for servicing.”¹⁷ Although fiber-optic lighting offers creative solutions, it has some drawbacks. Glass fibers dissipate UV light, but plastic fibers require UV filtering. The longer the length of fiber, the more loss of light occurs at the endpoint. Furthermore, severe bending of the fibers will result in extreme light loss, a consideration in configuring fiber placement. Finally, a museum would need to assess the environmental benefits into a cost-benefit analysis. In some cases, overall energy cost savings may not offset the expense of implementation.

Hybrid solar lighting (HSL) is one of the newest technologies in the lighting field. HSL uses solar power and fiber-optics to channel sunlight into an enclosed space while simultaneously directing infrared (IR) to a concentrating thermo-photovoltaic cell that converts it into electricity. Sunlight is tracked throughout the day using a parabolic dish. Sensors are used to maintain a constant level of illumination by supplementing sunlight with traditional electric light in special hybrid lighting fixtures.¹⁸ Because hybrid solar lighting pipes sunlight directly to the light fixture, the process is far more efficient than photovoltaic cells, which convert 15 percent of sunlight into electricity and then change the electricity back into light, resulting in the use of only 2 percent of

the original sunlight. As with all fiber-optic cables, the longer the cables are the more light they lose.¹⁹ Because the incoming natural light is full-spectrum sunlight, light fixtures specifically designed for exhibiting objects and filters may make this technology applicable for museums in the near future.

Lastly, museums have experimented with natural light use in galleries. By diffusing direct sunlight and creating complex systems that track and control sunlight, museums can take advantage of natural light while simultaneously avoiding the harmful effects of UV rays. A report by David Behar Perahia on the use of daylight in museums cites several institutions in Europe and the United States that have successfully integrated architectural designs that use natural daylighting. The Menil Collection in Houston, Texas, uses a system of ceiling louvers, skylights, and large windows that allow for diffused full-spectrum natural lighting in the galleries. The Beyeler Foundation in Basel, Switzerland, has a glazed ceiling that also employs the use of louvers and brise-soleil.²⁰ Brise-soleil, an ancient architectural shading technique, appears to be experiencing a revival and is used in the new wing of the Milwaukee Museum of Art and the Louvre Abu Dhabi in the United Arab Emirates.

Ultimately, a suitable compromise between the needs of objects and museum visitors must be achieved. A report produced by the Getty Museum Lighting Research Project noted that “when applying light damage mitigation techniques simultaneously to maximize conservation, compromises are necessary—display times are limited, and light levels may be so low that they challenge perception through skewed color rendering and reduced detail.”²¹ David Behar Perahia attributes this challenged perception caused by inadequate lighting to museum fatigue, a well-known phenomenon identified by Benjamin Coleman in 1916.²² David Clinard stated that “traditionally, color quality has been and still is one of the most critical concerns for displaying art objects.”²³

Creative lighting strategies throughout a museum building can benefit an institution’s budget, staff, visitors, and collections. The use of motion sensor lighting and dimmers reduce both object exposure time (thus, slowing deterioration) and energy use (thus, lowering electricity bills). Other forms of

nontraditional lighting such as the Solatube, a lighting strategy that redirects sunlight down a reflective tube and diffuses light within an interior space, can incorporate natural light into non-art spaces such as offices, cafes, museum stores, or meeting rooms, creating a more appealing atmosphere for staff and visitors. LEDs, fiber-optic lighting, HSL, and natural light have the potential to benefit museum objects as well as the Earth’s natural environment.

Heating, Ventilation, and Air Conditioning (HVAC)

Museums use twice as much energy as typical office buildings because while office buildings usually cool, heat, and illuminate from 9 a.m. to 5 p.m., Monday through Friday, museums often have extended hours and maintain constant climate control for collections.²⁴ Museum HVAC systems are complex, require constant monitoring, and are one cause of museums’ excessive energy use.²⁵

A typical HVAC system adjusts air temperature and humidity. The air is first heated or cooled (the cooling removes humidity from the incoming air), then may be humidified by water heaters or boilers before entering the galleries or storage areas. In most systems the air passes through three filters: the first removes large particulates, the second removes fine particulates, and a carbon filter removes some vapors. These processes are controlled by electronic sensors or a central computer system. Clearly, HVAC systems use a great deal of resources and electricity.²⁶ Nevertheless, even in an HVAC system, there are opportunities to reduce waste and decrease costs. One alternative is the carbon filter change-outs. Usually, carbon filters are changed every twelve to eighteen months. The old filter, made of plastic, metal, cardboard, and carbon, is disposed of in its entirety. However, the carbon could be exchanged for fresh carbon and the used carbon could be sent to a reclaiming company for reactivation (discharging of the contaminants) so that it could be reused.²⁷ In addition to saving money and keeping filters out of landfills, this method would establish a waste-free recycling system for carbon.²⁸ This is just one example of how creative thinking could reduce the overall cost of operating HVAC systems.

Temperature and humidity guidelines also offer energy and cost reduction possibilities. The mechanisms of decay for objects can be attributed to three situations in humidity and temperature control—too low, too high, and too much fluctuation. The resulting damage can be chemical, mechano-physical, or biological.²⁹ Most museums follow the guidelines for humidity and temperature control as presented by Garry Thomson in *The Museum Environment*, first published in 1978, with a second edition in 1986.³⁰ Based on what was then known about how materials interact with their environment and the limitations of museum HVAC equipment, Thompson recommended a narrow range of fluctuations of humidity of ± 4 percent or 5 percent. However, Thompson stated that “the tolerance usually quoted of ± 4 or 5 percent RH is based more on what can be expected of an air-conditioning plant than on what exhibits can actually stand without deterioration, which is not known in any detail.”³¹ Despite this, museums long adhered to narrow ranges of fluctuations, sometimes even implementing stricter guidelines of ± 2 percent. Research published in 1994 on the specific properties of materials by Marion P. Mecklenburg, Charles S. Tumosa, David Erhardt, and Mark McCormick-Goodhart of Conservation Analytical Researchers (CAL) widened the range of humidity control to 50 ± 15 percent.³² Although the results were considered highly controversial at the time, gradual acceptance has yielded the current Smithsonian-recommended ranges of 45 percent ± 8 percent relative humidity and $70^\circ \pm 4^\circ\text{F}$, and further research has reinforced the rationale for relaxing the old guidelines (see discussion in “The Constancy of Change and Occurrence of Challenges” in CHAPTER 1A, “A Very Brief History of the Profession,” and “Section 4: Additional Information” in *Sustainable Preservation Practices*³³).

Applying more realistic guidelines nationally could result in significant energy savings. Mecklenburg, Tumosa, Erhardt, and McCormick-Goodhart note that “ongoing implementation of the new guidelines in Smithsonian museums resulted in cost savings of \$2.7 million in just the second half of 2006 (out of \$32 million total energy costs for all of 2006), and \$1.5 million in the first quarter of 2007.”³⁴ Ad-

ditionally, allowing for seasonal drift to occur (a slow adjustment in the humidity and temperature set points to allow for seasonal change) can result in monetary savings by maintaining an environment that correlates more closely to outside temperature and humidity. The building envelope (the separation between the interior and exterior environments) must also be considered, especially in older buildings, because introducing high humidity into the air can cause condensation to develop within the building envelope, which can then freeze and cause accelerated deterioration of the façade—thereby promoting mold growth. Acceptance of the Smithsonian-recommended temperature and humidity ranges and seasonal drift can produce substantial savings from diminished energy usage while still maintaining safe environmental controls for the objects.³⁵

Materials and Products

Along with lighting and HVAC systems there are other operations under a registrar’s purview that can become more environmentally friendly. One way to review daily tasks is to apply the familiar “Reduce, Reuse, Recycle” mantra, maximized by a fourth “R”—Rethink. Ask questions related to the three R’s when deciding how best to accomplish a project. What is the minimal amount of material needed to properly store, display, or ship an object? Will waste be generated from the action and are there systems in place to store, recycle, or dispose of that waste properly? Is the product needed for long- or short-term use? Answers to these questions will often lead to sustainable alternatives, and such analysis is far more manageable than detangling the web of issues posed by the question, “What are the economic, social, and environmental costs to executing this task?” The following will discuss potential products and practices registrars should explore to align their departments with the goals of sustainability.

As indicated previously, there are differences between purchasing green versus sustainable products. Locating a collection care product that balances the triple weighted scale of sustainability—economy, society, and environment—is difficult in today’s global economy. Comparisons between raw materials are dependent on specifying the geographic location and

manner in which the resource is obtained, followed by how it is processed, where, and by whom. For example, one group claims that the agricultural plants hemp and kenaf, both rapidly renewable resources, have high yield rates, require minimal amounts of fertilizer, and have lower lignin contents than wood from trees, thus requiring fewer chemicals in the pulping process. A different group of people claims that tree plantations certified by the Forest Stewardship Council (FSC) prevent soil erosion, provide habitat for more species, and typically apply fertilizer once every crop rotation (every seven years) compared to once a year with annual agricultural crops.³⁶ Common among both groups is an argument against overconsumption and monoculture and agreement that even the greenest pulp mill generates some form of pollution. Ultimately, product choice is an act of compromise. However, if consumption is warranted—having first taken “Reduce, Reuse, Recycle, and Rethink” into account—it is important to support companies that have made the effort to incorporate some form of sustainability rather than none at all. The following will place the tasks of purchasing archival products, and packaging and shipping loans under the lens of sustainability.

Plant fibers are key ingredients in many archival materials. Sustainable alternatives to conventional paper products and textiles are available to other markets, but further effort is needed to bring appropriate products to the museum profession. It is possible to produce organic, nonbleached cotton cloth and to produce American National Standards Institute (ANSI)-certified archival paper from 100 percent postconsumer content without the use of chlorine.³⁷ Museums recognize their responsibility to educate and promote sustainability in the public sphere, so alternative products should be tested and everyday practices should be reviewed to determine their environmental impact.

Registrars can ask vendors if sustainable alternatives are available. The more the profession requests sustainable alternatives, the more industries will seek them out to maintain and build their customer base, such as the B- and E-fluted corrugated boards distributed by Gaylord Brothers are made with postindustrial waste.³⁸ These products meet the same archi-

val standards as corrugated board made from single stream pulp, however, their environmentally friendly qualities are not advertised due to concerns over a potential reduction in sales. This is a good example of the importance archival vendors place on consumer trust and how the industry could be encouraged to seek sustainable alternatives with collaboration and support from registrars.

The archival industry is considered a niche market. Due to its small size and specific product requirements, the industry is not able to withstand economic forces from larger competing markets. Suppliers struggle to maintain product quantity and quality as mills close down, merge, or move overseas.³⁹ However, the archival industry's small scale may lend itself to the support of smaller localized farms, manufacturers, and businesses. For example, the rapidly renewable plant—kenaf—used for paper production at mills with strict environmental standards is seen as an alternative to current archival paper sources and production. The potential for creating a sustainable, archival market, integrating local suppliers, could increase with support and demand from the museum, archive, and library professions.

Switching from traditional products to green products does not necessarily solve the sustainability issue, however. Product change does not equal behavior change. For example, using bio-composite board or the FSC-certified wood products for crate exteriors instead of traditional plywood does not reduce the amount of natural resources consumed and wasted. It is the system in which crates are used that is unsustainable, not the crates in and of themselves. Although it is important to incorporate more sustainable and green products and methods into the profession, such alternatives lose their luster if used within an inefficient and wasteful system. As with product choice, registrars could fill an important leadership position by fostering the development of new norms through collaborative research with service providers.

Loans and Traveling Exhibitions

Loans and traveling exhibits are two systems managed by registrars. These systems have an admirable, educational mission but consume physical and

financial resources in a single-use manner, producing a significant amount of museum waste. Three pitfalls of the current loan system that make it unsustainable are (i) a lack of support to facilitate the reuse of packaging and crating materials; (ii) the inefficient and polluting manner in which loans are transported; and (iii) the lack of environmental responsibility when creating and disposing of museum generated products.

The *Guide to Organizers of Traveling Exhibitions* lists exhibit agencies serving museums nationwide.⁴⁰ The amount of materials consumed and discarded each year is enormous if one considers that the Smithsonian Institution Traveling Exhibition Service (SITES) currently travels more than 50 exhibitions to 250 communities each year, and ExhibitsUSA travels more than 25 exhibitions (requiring nearly 200 crates).⁴¹ Crating and packaging is expensive and a large amount of museum resources are used to fund loans. Results from a 2007 online survey showed that out of 105 participating institutions, 29 reported ordering a total of 426 crates in 2006 for a cost of \$412,108. Unfortunately, disposal fees are inexpensive, and once-valuable materials are routinely thrown away with no regard to the associated environmental costs.

There is a significant price difference between purchasing new crates and retrofitting used crates. Results from the aforementioned survey show that 30 participants reported retrofitting 510 previously used crates for a total of \$38,563. This equates to an average of \$75.62 per crate instead of an average \$967.39 per newly built crate.⁴² Retrofitting crates not only reduces waste but also saves a significant amount of money. The argument could be made that costs associated with storage, and transporting empty crates would decrease any monetary savings. However, before adequate feasibility studies have been undertaken and a true life cycle analysis between reusing and building new crates occurs, it is premature to assume that crate retrofitting would not yield savings.

To facilitate reuse, crates must be stored. The National Gallery of Art retains a large collection of crates (approximately three hundred) that are stored and managed by a local fine art shipper. The museum typically retains medium-sized crates for ver-

satility of reuse and as a rule does not use a crate if it is more than twelve inches bigger than the artwork in any one direction. Although neither the museum or the shipping company keeps track of the number of times crates are reused or which ones are used the most, the museum estimates that 95 percent of single-object loans travel in retrofitted crates, at a third less than the cost of a new crate.⁴³

For those institutions that cannot afford storage, a cooperative warehouse system could be developed, managed, and collectively funded by local or regional museums. Crates could be leased, with resulting funds returning to the cooperative or to the participating museums. Alternatively, an independent third party could purchase, warehouse, and either lease or sell materials, similar to a construction salvage center. Art handling and exhibition companies could form similar partnerships and devise ways of profit-sharing when resources are needed by clients outside of the contractor's immediate service area. Although such systems would not satisfy every situation, they could reduce the production rate of new materials and provide a means for organizations to retain valuable resources. This model could also be followed for commonly used and discarded exhibition support materials beyond crates.

It is important to note that the European museum community has successfully instituted a crate leasing program. Several European crate companies have designed reusable crates, especially for two-dimensional works.⁴⁴ In general fine art crating companies in the United States do not believe a leasing system would be efficient because of the country's larger size and museum density differences in comparison to Europe. However, a modified system that approaches leasing from a regional perspective and promotes cooperation among independent crating companies should be explored in the United States if museums wish to carry out loans in a more sustainable manner.

Transport is the second aspect of loans that makes them unsustainable. Traveling exhibitions produce greenhouse gas emissions. Just one SITES exhibit, "The Burgess Shale: Evolution's Big Bang," traveled 20,044 miles, producing 38 tons of carbon dioxide. This is equivalent to 80 barrels of oil, and

6.3 passenger vehicles traveling 12,000 miles per year.⁴⁵ If traveling exhibitions are to continue, the field must develop alternative methods to rotate and transport them. Currently, where and when an exhibit travels is the outcome of variables presented by both the exhibit lender and the borrower. The content, cost, and size of an exhibit generally determine the borrower and hence the location, while the borrower's internal exhibit schedule—which may or may not be planned in advance—typically determines the dates. These variables often cause exhibits to travel great distances back and forth across the country. A new system in which lenders direct how exhibitions circulate based on geography, not time, could be developed. Exhibit companies often advertise works in progress to judge interest levels. This business strategy could be a means to establish schedules based on the location of interested borrowers. Exhibit websites could indicate when a particular exhibition would be available in a certain region. Such a system would continue to allow advanced planning for both lender and borrower but would reduce the frequency of long-distance round trips.

In conjunction with improved scheduling methods, exhibits could be transported using more energy-efficient technologies. For example, low to moderate security exhibits, especially those that do not contain collection objects, could travel by train. Comparisons between highway and rail transport have shown it is more economical to use trains for distances beyond 500 miles.⁴⁶ On average, railroads are three times more fuel efficient than trucks; railroads move a ton of freight an average of 404 miles on a single gallon of fuel. The US Environmental Protection Agency (EPA) estimates that for every ton-mile, a typical truck emits roughly three times more nitrogen oxides and particulates than a locomotive.⁴⁷ Museums and art-handling companies should consult with the railroad industry to explore current options and encourage the development of equipment and services that would facilitate a variety of museum shipments. Fine art transport companies could, therefore, expand their services to include intermodal transport. When highway transport is necessary, support should be given to companies that use energy-efficient technologies such as vehicle idling reduction initiatives

and auxiliary power units that reduce greenhouse gas emissions.⁴⁸ The EPA's website lists transport companies (e.g., rail, truck, and intermodal) that are a part of their Smartway Transport Partnership Program.⁴⁹

Finally, museum loans and exhibitions produce vast amounts of waste. Again, reuse is rare due to a lack of storage space, and the true cost of land-filling our waste is masked by inexpensive disposal fees. Recycling packaging components, which for the purposes of this essay means implementing a secondary use for a material, is rarely practiced. There are bins for soda bottles and office paper, so why not for foam and metal? There are regionally based online recycling communities such as Freecycle, so why not "Museumcycle"? The use of various museum forums and listservs often serve as a great registrar tool to reuse or find crates, material, boxes, and even museum furniture that can be reused by other museums.

There are options to reduce the amount of waste generated from loans. Scott Carlee of the Alaska State Museum stated the following about resource-saving practices in his museum:

We probably do more than most museums just because it is so expensive to get materials shipped up here. Therefore, material is more precious to us than to most museums. We will take apart a crate and reuse the wood for some other task or we will take apart exhibit walls and make crates out of them. For our traveling exhibits we have reusable crates that were custom-built for the shows that travel. We reuse whatever we can and when something just can't possibly be used one more time it is disposed of in a landfill. All burnable wood is usually given to someone to burn in their wood burning stove for heat. The biggest drawback is space to store the material before we can reuse it.⁵⁰

Museums in the lower forty-eight states should perhaps adopt an Alaskan state of mind when it comes to the life cycle of museum-generated products. Redesigning crating and packaging systems to increase recycling is a necessity. For example, gluing crate joints in addition to using typical metal fasteners impedes the breakdown of crates. Wood from crates

has been used by art organizations and businesses for sculptures and cabinetry or as fuel in ceramic kilns or furnaces. The use of cardboard instead of Coroplast or Gatorfoam would increase the percentage of packaging material that can enter the conventional recycling stream. Before purchasing a product, a registrar should determine whether or not the manufacturer has a recycling program. Sealed Air Corporation, the manufacturer of both Ethafoam and Bubble Wrap, for instance, has a mail-back recycling program.⁵¹ Materials sent back to one of their seven receiving facilities is reprocessed within the company or by an outside company. DuPont has a similar mail-back recycling program for Tyvek.⁵² Additionally, pack-and-ship centers frequently welcome packing supplies to support their operations, and the cleanliness and integrity are often not an issue.

CONCLUSION

Many museums and service providers are adopting green and sustainable practices. For example, Arthowe Fine Art Services uses solar panels on the company's roof, biodiesel in its fleet of vehicles, and recycles cardboard, wood, foam, and Bubble Wrap. In September 2008, the California Academy of Sciences opened the doors of its new museum, which received a LEED Platinum rating from the US Green Building Council and a second LEED Platinum award in 2011, making it the world's first double-platinum museum.⁵³ The building includes a 2.5-acre living roof, sixty thousand photovoltaic cells, denim insulation, and natural lighting from skylights and exterior walls of glass. The academy has an official statement on sustainability approved by its board of directors as well as a green team. Initiatives developed by the academy's green team have altered many routine operations and include the elimination of plastic bottles at all staff meetings; the reuse and recycling of packing supplies; bulk ordering; and the elimination of antibacterial soap, which is harmful to marine life. The academy recycles 60 percent to 65 percent of its garbage.⁵⁴ These institutions and individuals have taken a leadership role in the sustainable movement, and their efforts will help facilitate sustainable practices across the profession.

As stewards of the past, present, and future, registrars must continually assess how the products created for and by museums affect the world. They can update accepted standards of collection care and management to reflect environmental stewardship and take a leadership position in forming and managing a green committee within their institutions. Registrars can be active participants in the pursuit of a sustainable future by being open to new technologies, working with service providers to bring new products to the market, and collaborating with colleagues throughout the museum world. •

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28. Garth Elliot, Chief Engineer, Nevada Museum of Art, Interview October 6, 2008.

29. A. W. Brokerhof, *Applying the Outcome of Climate Research in Collection Risk Management*. Available at: <http://www.padfield.org/tim/cfys/mm/brokerhof/brokerhof.pdf> (accessed November 11, 2008).

30. G. Thompson, *The Museum Environment*, 2nd ed. (London: Butterworths, 1986).

31. D. Erhardt, C. S. Tumosa, and M. F. Mecklenburg, *Applying Science to the Question of Museum Climate* (November 2007). Available at: <https://www.conservationphysics.org/mm/brokerhof/brokerhof.pdf> (accessed August 6, 2019).

32. Originally named Conservation Research Laboratory (CRL), it was renamed Conservation Analytical Laboratory (CAL) in 1963 and Smithsonian Center for Materials Research and Education (SCMRE) in 1998. It is currently named Museum Conservation Institute (MCI); available at: <https://www.si.edu/mci/>.

33. Ford et al., *Sustainable Preservation*.

34. Erhardt et al., *Applying Science*.

35. See also the Getty Conservation Institute newsletter, *Conservation Perspectives*, for Fall 2018, devoted to research on managing collection environments. Available at: https://www.getty.edu/conservation/publications_resources/newsletters/33_2/index.html (accessed August 15, 2019).

36. The Forest Stewardship Council (FSC) is an international organization that has established policies and standards to protect forest ecosystems. Available at: <http://www.conservatree.org/paperlisteningstudy/LSForests.pdf> (accessed August 6, 2019).

37. American National Standards Institute (ANSI) oversees the creation, promulgation, and use of thousands of norms and guidelines. Cascades Fine Papers Group includes Rolland Enviro100, which is made of 100 percent postconsumer waste that is processed chlorine free in a plant that uses biogas and is a certified Permanent Paper by ANSI.

38. Postindustrial waste is leftover material created when manufacturing a product. This type of waste can be collected to be used in-house or by an outside party to make a similar or different product. In contrast postconsumer waste is material that has been used by a consumer and discarded at a recycling center such as used newspapers, plastic hordes, or aluminum cans.

39. Dolores King, Product Manager, Gaylord Brothers; interview August 25, 2008.

40. Available at: <https://www.americansforthearts.org/by-program/reports-and-data/legislation-policy/naappd/guide-to-traveling-exhibition-organizers> (accessed August 14, 2019).

41. ExhibitUSA, available at: <https://eusa.org/exhibitions/> (accessed August 6, 2019), and SITES FAQs, available at: <http://sitesarchives.si.edu/about/faqs2.htm> (accessed August 6, 2019).

42. Twenty-nine museums reported ordering a total of 426 new crates in 2006 for a cost of \$412,108, which averages to \$967.38.

43. Johnnie Mizell, interview March 2007; Sally Freitag, Chief Registrar, National Gallery of Art, e-mail correspondence September 26, 2007.

44. Hasenkamp, two- and three-dimensional (2-D and 3-D) crates, available at: www.hasenkamp.com; Turtle Box by Hizkia Van Kralingen, Netherlands, available at: www.turtlebox.com, also www.vankralingen.com; Pegasus

Packaging Crate by Helicon: The Conservation Specialist, Netherlands, available at: www.helicon-cs.com.

45. The average tractor trailer, fully loaded, gets six miles per gallon. Carbon dioxide data was calculated using “The Greenhouse Gas Protocol Initiative’s Sector Tool, CO₂ Emissions” from Transport or Mobile Sources, available at: <http://www.ghgprotocol.org/calculation-tools/all-tools> (accessed August 7, 2019), and US Environmental Protection Agency Greenhouse Gas Equivalencies Calculator, available at: <http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator> (accessed August 7, 2019).

46. H. Conlon, Hub Croup, Inc., interview April 5, 2007.

47. US Department of Transportation, Freight movement and air quality. Available at: https://www.fhwa.dot.gov/Environment/air_quality/research/effects_of_freight_movement/chapter02.cfm (accessed August 7, 2019).

48. Environmental Protection Agency, SmartWay Transport Partnership. Available at: <http://www.epa.gov/otaq/smartway/index.htm>.

49. Available at: <https://www.epa.gov/smartway> (accessed August 14, 2019).

50. E-mail correspondence (Warden) April 19, 2007.

51. Available at: <https://sealedair.com/recycling-plastic-foam-and-paper-packaging> (accessed August 14, 2019).

52. Available at: <https://www.dupont.com/products-and-services/packaging-materials-solutions/industrial-packaging/articles/recycling-information.html> (accessed August 14, 2019).

53. Available at: <https://www.calacademy.org/press/releases/the-california-academy-of-sciences-receives-second-leed-platinum-rating-from-us-green> (accessed August 14, 2019).

54. Available at: www.calacademy.org (accessed August 6, 2019).

